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FRIDAY, NOVEMBER 23, 1923.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2).

ONE-HUNDRED-AND-SEVENTIETH SESSION, 1923-1924.

NOTICES.

NEXT WEEK.

TUESDAY, NOVEMBER 27th, at 4.30 p.m. (Dominions and Colonies Section.) VISCOUNT BURNHAM, C.H., LL.D., D.Litt., M.A., "The West Indies." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

WEDNESDAY, NOVEMBER 28th, at 8 p.m. (Ordinary Meeting.) SIR HENRY JOHN GAUVAIN, M.A., M.D., M.Ch., Medical Superintendent of the Lord Mayor Treloar Cripples' Hospital, "The Effect of Sun, Sea and Open-air in the Treatment of Disease." LORD DAWSON of PENN, G.C.V.O., K.C.M.G., M.D., F.R.C.P., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

COUNCIL.

A meeting of the Council was held on Monday, November 12th; Present:—

Lord Askwith, K.C.B., K.C., D.C.L. (in the Chair); Lord Blyth; Sir William Henry Davison, K.B.E., D.L.; Mr. Edward Dent, M.A.; Sir Robert Hadfield, Bt., D.Sc., D.Met., F.R.S.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Major Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; Dr. William Henry Maw, M.Inst.C.E.; Mr. John Slater, F.R.I.B.A.; Sir George Sutton, Bt.; Mr. James Swinburne, F.R.S.; Mr. Alan A. Campbell Swinton, F.R.S.; Mr. Carmichael Thomas; and Dr. J. Augustus Voelcker, M.A.; with Mr. G. K Menzies, M.A. (Secretary of the Society), and

Mr. S. Digby, C.I.E. (Secretary of the Dominions and Colonies and Indian Sections).

On the nomination of H.R.H. The Duke of Connaught and Strathearn, President of the Society, Sir Dugald Clerk, K.B.E., D.Sc., LL.D., F.R.S., was elected a Vice-President of the Society and a Member of the Council.

Arrangements for papers to be read after Christmas were further considered.

Other formal business was transacted.

SWINEY PRIZE.

Attention is drawn to the fact that the last day for receiving entries for the Swiney Prize is November 30th, 1923.

The prize is a cup, value £100, and money to the same amount, and is offered on this occasion for the best published work on general Jurisprudence.

Any person desiring to submit a work in competition, or to recommend any work for the consideration of the judges, should do so by letter, addressed to the Secretary of the Society, by the date mentioned above.

Notice of the competition was printed in the *Journal* of June 1st, 1923.

SECOND ORDINARY MEETING.

WEDNESDAY, NOVEMBER 14th, 1923; MR. ALAN A. CAMPBELL SWINTON, F.R.S., Ex-Chairman of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Burnham, Walter Witt, London.
Jack, James, New Cumnock, Ayrshire.
Jacques, Gilbert J.P., Ontario, Canada.
Markgraf, Miss Agnes, The Hague, Netherlands.
Peterson, President Elmer George, Ph.D., A.M., B.S., Logan, Utah, U.S.A.

A paper on "Téléphotographie, Télautographie, Télévision (avec Expériences et Projections)" was read by M. EDOUARD BELIN.

The paper and discussion will be published in a subsequent number of the *Journal.*

REPRINT OF HOWARD LECTURES.

The Howard Lectures on "The Development of the Steam Turbine" by STANLEY S. COOK, B.A., M.I.N.A., M.I.M., have been reprinted from the *Journal*, and the pamphlet (price 2*s.*) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

PROCEEDINGS OF THE SOCIETY.

FIRST ORDINARY MEETING.

WEDNESDAY, NOVEMBER 7TH, 1923.

LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair.

The Chairman delivered the following Address :

EXHIBITIONS.

By LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council.

With the coming of the great British Empire Exhibition at Wembley in 1924, it may be well to reflect for some brief time on the subject of Exhibitions, and even to consider some aspects of the possible bearing of such an Exhibition as this on Science, Art and Industry. The importance of the subject is further enhanced when it is remembered that an Empire Economic Conference is even now being held between the principal representatives of all parts of the British Empire, and that the coming Exhibition is specially to illustrate the products of the British Empire in Science, Art and Industry.

It seems to be particularly apposite that in an inaugural address your Chairman should consider the subject, although, owing to the numerous reports, lectures and articles which have emerged from a succession of exhibitions, much that could be said must necessarily be repetition of ideas and statements already published. Repetition is at least surrounded by many advantages which I need not now discuss, but the apposite character of the subject arises from the fact that, as Sir Henry Trueman Wood remarks in his admirable History of the Royal Society of Arts, "it may certainly be claimed for the Society that it initiated the idea of Industrial as well as Fine Art Exhibitions." He adds that "there seems no doubt that the earliest industrial Exhibition of which there is any record, was the Exhibition, held by the Society of Arts in 1761, of Agricultural and other Machines, for which the Society had offered prizes."

Sir Henry mentions Exhibition after Exhibition supported by the Royal Society of Arts, culminating in the great Exhibition of 1851, and the various efforts which since that day have been made in this and other countries, until Exhibitions have

become a natural feature called for at intervals in all parts of the world. No longer are they viewed with the surprise evoked by the small but brilliant display given in 1851, that great work for which the Royal Society of Arts was so largely responsible, and with which the name of Prince Albert, the father of our President, will ever be identified. May our Royal Family ever continue to maintain that honourable tradition! A concise historical account of these and subsequent exhibitions can be read in Sir Henry's book, which every member of the Royal Society of Arts might well purchase, and it may be mentioned that in 1851 Prince Albert suggested that a series of lectures should be given at some of the Society's meetings "on the probable bearing of the Exhibition on the various branches of Science, Art and Industry," a proposal which led to 24 lectures by eminent lecturers and may be a precedent for persuading speakers of the present day to give us in this hall the advantage of their study of the Exhibition.

A list of exhibitions from 1851 down to 1907, prepared by Sir Henry Trueman Wood, was published in the *Journal* of November 8th, 1907 (Vol. 55, No. 2868.) The list is intended to include, besides the genuine International Exhibitions, all industrial and technical exhibitions of an important character. The list, for the 56 years between 1851 and 1907, takes note of 374 exhibitions, of which 71, or more than one-fifth, were held in London. They were of very varying character, but if numbers only are taken, the rest of the United Kingdom and France come next with 40 each, the United States held 24, and Australasia 22. I think later officers of the Society might well prepare a subsequent list and keep the record up-to-date.

Making, therefore, no apology for considering the subject before this Society, I would initially emphasize the fact that exhibitions have been marked by varied and continuous growth. During the course of the 150 years new theories and aims have necessarily been developed. Unless there had been elasticity and adaptability, it is plain that so world-wide a system would not have come to stay, and in point of fact, the theory has extended, as it were, both vertically and horizontally. No particular laws seem to have governed this extension. In truth, growth has been very haphazard. Given a show, such as that of agricultural and other machines in 1761, the horizontal extension has enlarged the number and types of agricultural machines exhibited, and added to the exhibition of agricultural machines every conceivable kind of business connected with them, widening the band to include earths, animals and vegetables. Given, again, a show such as that of 1851, the vertical extension has embraced more and more countries, more and more products, and more and more additions and side shows only remotely connected with the main principle. The growth of the vertical extension has been apt to become so great that it has occurred to promoters that sectional exhibitions must be held, such as for Fisheries and Inventions, embracing the conception that by taking different sections the general exhibition could be broken up, and that exhibitions could be held every year, thus, in a manner, again returning to the horizontal method. The haphazard growth of the system brought its own condemnation. Enough interest could not be aroused in each special section, enough time was not given to the preparation and adequate presentment of the sections, and the public became frankly bored with a similar yearly exhibition of side shows, of which the novelty had worn off, with some industry attached to them in which they took minor interest, and in which the scientists and the industry itself found themselves neither properly prepared nor in any better position than practical relegation into a side show which gave a name to the exhibition for the current year.

If distrust and doubt began to be prevalent in this country, they were not destroyed here, and indeed spread to other countries, when calls were made for exhibitions in Paris in 1900, St. Louis in 1904, and again in Brussels in 1908. The speed with which exhibitions followed one another, the heavy expense and difficulty of organisation inseparable from exhibitions such as that of St. Louis, and in many cases the doubtful advantages to manufacturers seemed to be onerous burdens. It is to the credit of this country that it initiated an attempt to bring some order into the system, not only in Great Britain, but, after the Brussels Exhibition, into the arrangements which could be made with other countries as to the times and scope of Exhibitions. So far as this country was concerned, the initiation arose from the importance of enquiring into the expenditure of public money. A Com-

mittee was appointed "to enquire and report as to the nature and extent of the benefit accruing to British Arts, Industries and Trade from the participation of this country in Great International Exhibitions; whether the results have been such as to warrant His Majesty's Government in giving financial support to similar exhibitions in future, and, if so, what steps, if any, are desirable in order to secure the maximum advantage from any public money expended on this object."

The Committee, in their report, illustrated the haphazard methods which had been customary. They remarked that "the participation of this country in great international exhibitions has never been governed by any continuous or clearly defined principles." They also stated: "One of the most striking facts revealed by an examination of the Official Reports of the Royal Commissions, which have acted on behalf of this country in the past, is the absence of continuity by which their work has been characterised. The participation of Great Britain in each successive exhibition would appear to have been created as if it were an entirely new problem, unconnected with those that had gone before, and little, if any, attempt seems to have been made to apply to one Exhibition the lessons derived from another." My study of the Reports leads me to the conclusion that the Committee correctly stated the position, although Cole and Owen had done as much work as pioneers could well do.

The effect of this system was reflected in the result, which was thus described: "There appears to be little doubt that, taken as a whole, the British sections at all the more recent exhibitions have not afforded an adequate and satisfactory representation of the nation's industries. With the exception of the Arts Exhibits, which at recent exhibitions have undoubtedly attained a high degree of excellence, the goods exhibited in the British sections would appear to have been of very uneven quality. Many of the more important industries of this country, if represented at all, were represented by firms of minor importance. The exhibits of many of these firms were often creditable to themselves, but it cannot be said that they were representative of the best productions of the country, or that they compared as a whole favourably with the exhibits of other countries." The last sentence appears to me to be too drastic a criticism.

Any praise in this summing up was distinctly faint, and certainly did not say much in favour of British power of organization.

In consequence of the Committee's report, an Exhibition Department under the Board of Trade, attached to the Commercial Department, of which I was then the head, was established here, and after the Brussels Exhibition that Department was able to take steps for better International arrangements in regard to the holding of exhibitions. It owed, perhaps, its influence to the manner in which the British section at Brussels was worked, and, after a disastrous fire, restored speedily and well.

The whole of that Exhibition would have come to grief if this country had failed to exhibit, and one of the best sections had been non-existent. It is to the credit of the Government of the day, and the efforts of Lord Lytton, that £60,000 was at once given to resuscitate the section, and to the credit of our industries that manufacturers, including Sir Frank Warner, a member of your Council, worked hard to produce a fine section, and, incidentally, to earn much gratitude from Belgium.

So successful was the exhibition, that other countries, of which I think Brazil was the most prominent, wanted exhibitions of similar character. Brazil held an Exhibition on the Centenary of Independence, which was largely supported for political reasons, but the experience of the cost to governments and to manufacturers, and also of the time and trouble involved, had been a valuable lesson. Our country took the lead in an endeavour to put on some reasonable basis, in collaboration with other countries, when and where exhibitions were to be held; and what exhibitions should receive other support beyond the competition of such manufacturers as desired to participate. It is too much to force manufacturers continuously to send their goods to the ends of the earth, to any and every exhibition which may be announced, however badly the preparatory work has been done, and however little interest or result may be acquired in the country where the exhibition is held.

So far as international exhibitions are concerned, the efforts of promoters require strict examination, and casual faddists or profitmongers should be discounted. Anyone can exercise ingenuity in suggesting

exhibitions or hope to gain notoriety or profit by their promotion, but these efforts ought, by reasonable arrangement, to be sifted, and these "highwaymen" treated at their proper worth.

The result of our endeavours ended in a Convention signed at Berlin in December 1912 by 15 European countries and Japan, but never ratified. Its main objects were "to limit the number of great international exhibitions and to establish a uniform code of regulations with a view to reforming their organization and administration." It was laid down that at least three years must intervene between great international exhibitions, and useful rules on official patronage, uniform regulations, fire, juries, and the suppression of abuses were proposed. At some future date ratification of this Convention, with such amendments as later practice can suggest, may be desirable.

The study of the work of this Department and of the literature of exhibitions, leads me to the conclusion that in the carriage of exhibitions at least three main principles ought always to be borne in mind, the principles of careful preparation, of efficient organization, and of sympathetic management both before and after the exhibition.

The principle of careful preparation would include the abolition of the haphazard growth of which I have spoken. It would include consideration of the scope of the exhibition, the object, aim, and value; and, if the scope of an exhibition, whether international or local, has been properly considered and defined, and a competent authority has decided that an exhibition is desirable and ought to be held, either in any particular place, or for any particular sections of industry, the succeeding step is that there should be ample time for preparation and plenty of spade-work given to the foundations.

Many an exhibition has gone to grief for lack of due perception of the importance of time and spade-work. Exhibitions cannot be improvised and brought into being by saying that they should be held. The history of exhibitions is strewn with accounts of the losses and disappointments caused by the lack of that very obvious principle, the necessity of preparation; and, owing to the lack of machinery for determining whether the participation of this country was desirable or not, decisions to take part in an exhibition have been often taken by our Governments at too late a date to permit of proper preparation of the British sections. Too many masters, lack of organization, slackness or delay on the part of sections of industry or representatives of particular countries, are only a few of the many factors which may lead to trouble. Proud should be the managers of any exhibition who may be able to say on the day of opening: "There is a completed work to which we have nothing further to add."

The second principle, akin to early preparation, is that of efficient organization. Each country or each trade may require organization of its own, but there must necessarily be some central authority to hurry up the sluggard and, as far as possible, to prevent schemes or plans alien to the exhibition as a whole. Such organization ought to be settled from the very first, or else there are sure to be misunderstandings or even disaster. We in this country, in our usual English way, seem to repose confidence in Committees. The coming Exhibition started with an Executive Council, Committees of Management, Finance, Accounts, etc., and General Manager, whose place has now been taken by an Administration Committee, commonly called "The Big Five," under whom work a Director of United Kingdom Exhibits, a Controller of General Services, a Controller of Stadium and Entertainments, and a Finance Manager. Our Committees are not confined to a central committee, but extend to sub or minor advisory committees relating to each trade and branch of a trade. These committees expand still further—to conferences and to congresses. Thus it is stated that, for the coming Exhibition, "the Textile Institute of Manchester, in co-operation with the leading textile federations and associations, is organizing an Empire Textile Conference. A general committee has been formed composed of leading men in the industry. The object of the conference will be to promote the commercial, technical and scientific knowledge of the textile industry, to bring about a closer relationship with various parts of the Empire. and to discuss problems of production, distribution and consumption, with a view to co-operation where possible."

"The Convention of the Associated Advertising Clubs of the World, which is being organized by the Thirty Club of London, will make Wembley the focus of all the principal advertising organisations of

the world. The Institution of Mining and Metallurgy and the Decimal Association have also arranged to hold conferences, while among the subjects still under consideration are migration, education, child welfare, labour, public health and retail distribution." The biggest conference will be the World Power Conference.

"Apart altogether from open conferences of this kind, many industrial and other organizations have already arranged to hold their annual congresses at Wembley, where they will have the benefit of the experience and counsel of overseas visitors, and a committee has been established to settle about these and other congresses." And then there are the juries, but of these more anon.

Other countries have had systems different from our own. France, where exhibitions were so fostered by the first Napoleon, and where, since 1851, exhibitions have been so remarkable, has a system which has been thus described: "The principal feature of the French system is that practically the whole of the work of organization is performed by a Committee of the Exhibitors themselves . . . nominally under the control of a Commissioner General appointed by the Ministry of Commerce. All the active work of preliminary investigation and organizing the exhibits is undertaken by the Committee, and practically the whole of the cost of the French section, with the exception of exhibits of an unremunerative nature, such as Education, Art, Social Economy and the like, is borne by them." The Committee is controlled by a Council elected by themselves every three years, and there are Executive Committees for (1) Propaganda, (2) Enquiry and Preliminary Organization, (3) Entertainments and Receptions, and (4) Accounts and Publications. By this system continuity has been obtained, there has been self-government by industry, and the general excellence of French exhibits is a strong testimony to their power of organization.

In Germany before the War, the system was entirely different. The organization, preparation, and supervision of the German sections was done by a single official, nominated by the Chancellor and appointed by the Emperor. This Commissioner was responsible for large sums paid by the Government, and his power was practically supreme. Any member who saw the large isolated German section at Brussels will realise that by this means unity of scheme was obtained, that heavy expenditure must have been incurred, and that a peculiar effort seemed to have been made to produce an effect and to attract the public by an unusual, if not bizarre, display.

We in this country have, owing to lack of continuity, had no entirely fixed system. In the more important exhibitions, though not in the coming Exhibition, the British section has usually been in the hands of a Royal Commission, but the Committee of 1906 reported that "the evidence obtainable with regard to the organization of the British sections at most of the exhibitions is for the most part of a very vague and uncertain nature. The information contained in the official reports is often incomplete, and it is difficult to form from them any clear idea as to the manner in which the grants were expended and the exhibits organized. . . . As a general rule, it may be said that the assistance afforded by the Government to British exhibitors has been confined to the provision of an organization which would enable them to display their goods if they desired to do so at their own expense. With but very few exceptions, the whole cost of the preparation, transport, insurance, installation, and decoration of the exhibits appears to have been borne by the exhibitors themselves, and few inducements were offered by the Organizing Body with a view to securing the co-operation of firms who were unwilling to exhibit for their own personal profit."

The result of this sytem was scathingly criticized in the report of His Majesty's Commissioners after the Paris International Exhibition of 1900. They made remarks like these: "In the British section every exhibitor used his space in accordance with his own fancy and showed what he pleased." The appearance of "the undignified collection of show cases of different sizes and designs which filled the British space was little less than painful." "As a rule, a British manufacturer will only exhibit if he can select his own goods, and display them in his own way, and in his own show case. He is impatient of advice; he will not submit to dictation; he will not share a show case with others; nor will he join with others to adopt a uniform plan of arrangement."

The result of this extreme individualistic attitude, though it has some merits in principle, prevented any really compre-

hensive display of the principal manufacturers of the country. There was delay before Royal Commissioners, if any, were appointed. Other countries got the best sites. Insufficient space was obtained. The best firms often stood aside and failed to exhibit. There was competition for insurances, freight, and labour, with undue expenditure. One exhibit might be completed, while others all round it were unfinished, empty, or disfiguring; and visitors will not face sawdust.

An attempt was made at St. Louis with some success in the direction of collective exhibits, and the advice of the Paris Commissioners that the best hope of the future lay in well-organized collective combination, coupled with symmetrical arrangement, has borne more or less fruit. Those Commissioners, however, repeated the warning, "It is essential that the preparation of such exhibits should be begun in ample time."

It remains to be seen whether the "Big Five" will have successfully organized the coming Exhibition, but from the notices of their efforts, it would appear that a distinct advance, in spite of the very many diverse lines, old and new, upon which they have to work, will be shown in 1924. No prejudicial opinion should be based upon the incidents of one football match; and indeed, the experience then gained may have been very serviceable. If their success transcends any previous experience since 1851, lessons of value may be obtained which should indicate the best methods of preserving continuity in the future. I trust that they may not be lost sight of.

The third principle to which I alluded was sympathetic management. There must be executive officers, and in 1906 it was reported that "the same lack of continuity that has characterised the appointment of Royal Commissions in the past is also noticeable in the selection of executive officers." The Committee said the Secretary of the Royal Commission, when established for an Exhibition, had not only done much of the active work of organization, but in most cases had acted as the Commissioner General of the Exhibition itself, and had usually taken charge of the work of installation, decoration and general management of the British section. It is obvious that work of this character requires first class men, involving, as it does, not only energy, application, training, and experience, but also great sympathy and power of dealing with men. In the past Sir Henry Cole was a very dominating personality, and at a later date Sir P. Cunliffe Owen was well known for his energy and skill. But in 1906, it was said that though it was "mainly upon this one officer that the success or failure of the national display as a whole depends, it is not a little surprising to find that in no two of the more important exhibitions in which this country has taken place since 1878, has the post of Secretary and Commissioner-General been filled by the same man." Sir P. Cunliffe Owen, secretary at Paris and Vienna, may possibly be an exception to this statement.

That the work of management is no sinecure, may be aptly illustrated by the extract I have already quoted from the report of the Paris Commissioners in 1900, on the extreme individuality of the British exhibitor. In 1908 Mr. U. F. Wintour took up the office of manager and did remarkably well in the Brussels Exhibition. He continued his services as a Civil servant on behalf of the Exhibitions Department of the Board of Trade at other exhibitions, worked in all the initial stages of the present Exhibition as a general Manager, and, I understand, receives payment in an advisory capacity at the present time. The work, however, is too much for one man, though the division of authority is not an easy problem to solve. In our usual way we now have a Committee, or Board, aided by other Committees, amongst whose members it is pleasant to know that Colonel H. W. G. Cole, grandson of Sir Henry Cole, who won fame in 1851 and 1862, is a Chief officer of the British Government Pavilion and in charge of some remarkable exhibits. It is to be hoped that the general experience may lead to a report on the best method of dealing with the difficulties of the future, and laying down right lines for a developing institution, and for continuity, even if great international, or Empire, exhibitions do not often recur, and give place to the less expensive exhibitions of special products or trades.

Among other general questions which have been always debated, may be mentioned the subject of juries, and the question of the value of exhibitions. As to juries, it is difficult to dispense with them, and still more difficult to ensure that their awards should not be too numerous or too open to criticism. Allegations of intrigue and favouritism are easy to make, and difficult to

controvert. Continuity, expert knowledge, sufficient numbers, methods of appointment and selection, are factors which have to be considered. The work of judging requires care and knowledge. The Berlin Convention laid down some useful rules, suggesting divisions into grades and restriction of numbers, on the principle that juries would have to continue. On the whole, I think it may be said that British jurors have been remarkable by the care which they have exercised. It is perhaps because we are here so accustomed to the jury system. At any rate, it is a traditional system in this country, and though it has from time to time been criticized as unsatisfactory, it has been so generally used ever since 1851, and is in such general demand for exhibitions of all kinds, such as shows of the Royal Horticultural Society, that its continuance almost appears to be certain in many exhibitions, though wholesale and indiscriminate distribution of awards may be curtailed. The methods of judging and the employment of right men, are, of course, details in which improvement by experience can from time to time be made. It may be that for the avoidance of rivalry between mother-country and dominions, and between the overseas countries themselves, in this particular exhibition at Wembley, so impracticably vast for correct grading in terms of excellence and efficiency of products, awards and the rivalry of awards, and the employment of juries, can be reduced or even eliminated. The proposal has been made and has received wide acceptance. If that course should be taken the effect would be interesting to judge and might indicate variant experiments in the future.

On the question of the value of exhibitions much might be said. It is difficult to estimate the value to the country as a whole, or to the manufacturers and exhibitors in general or in particular. For the country as a whole a good exhibition can scarcely be without considerable value. Education and knowledge are increased. Invention and the application of science to industry are stimulated. A great deal of innocent amusement is given. There is a certain binding link which results from the common purpose. To manufacturers and exhibitors in general I am inclined to think the value is also great. Advertisement at the present day improves by leaps and bounds, and an exhibition is a vehicle by which ready and great advertisement may often be obtained. New and unknown firms have an opportunity of coming into notice. Novelties and articles for which there is little demand become known, and may quickly appeal to the consuming public. There is, for instance, the well-known story of Bass's beer, and how the firm made their fortune by supplying that beverage in the thirsty summer of 1851, and never looked back since. And, lastly, not only are the Art sections generally the most attractive parts of the Exhibition, but have generally proved of value to artists themselves.

As regards particular firms or individuals, the evidence must necessarily be mixed. There can be no statistics of benefit. Firms are not likely to disclose, even if they can gauge, the actual results direct or indirect, which they have obtained. They will judge exhibitions by what they think is the result. In some cases they will grumble at the trouble, the expense, and the time. They will allege disclosure of inventions, the unfair copying of their exhibits, and even the copying of a trade in which they hoped to have a monopoly.

In the Report of the Commissioners for the International Exhibitions at Brussels, Rome and Turin, in 1910 and 1911, it is remarked that "participation in an International Exhibition, like other forms of advertisements, may lead to results which it is very difficult, if not impossible, to trace, and in considering benefits derived from an exhibit it should, therefore, be borne in mind that, although no actual increase in business may be traceable, abstention from the Exhibition might have resulted in loss of prestige and consequent diminution of sales."

Perhaps the most important point for any firm or individual to consider is to have a capable agent, so that the exhibitor may not have to complain that success has not attended efforts in comparison with others owing to faults which may be due to bad organization, bad salesmen, or bad methods of showing exhibits.

These general remarks only indicate some factors in a large subject, and some of the principles and questions which I believe are vital to it. A present question, the British Empire Exhibition, is immediately before us, a mere stepping stone, I think, in the developing future, but a stepping stone of great importance, from which many lessons may have to be

deduced. Not the least of these lessons is the fact that this is the third great exhibition held in this country after the exhibition of 1851 and the comparatively unsuccessful exhibition of 1862; and that our attention is continually directed back to the exhibition of 1851, of which the material results now visible are the building called the Crystal Palace, the Victoria and Albert Museum, and the Science and Art Department, with many minor derivatives such as the recent exhibition of "Industrial Art of To-day," by the British Institute of Industrial Art, at the Victoria and Albert Museum. That Exhibition of 1851 marked an epoch. Will this? The first impression coming to my mind in the consideration of 1851 is the vast gulf between that epoch and this present year, particularly in the aspirations and ideas of the world at that time, and in the developments of art, science and commerce, which have, in fact, occurred. The second is but an idle speculation, whether in the year 2000 the same result will have occurred, and all our aspirations and ideas and all the developments of art, science and commerce, marching with the increased velocity of accumulating force, will have taken a course utterly different from any present anticipations, but proceeding, as they have done since 1851, in a manner scarcely noticed by the overlapping generations of men.

There are but few men now who can throw their minds back to 1851, but without appeal to their memories, it will be sufficient for the purpose of indicating the gulf to mention a very few documentary proofs. The most salient example I can find is contained in the changes seen, and considerably aided by, the late Admiral of the Fleet, Sir Arthur Wilson, whose life has recently been published. That officer fought in the Crimean War in 1855, in the Egyptian War at El Teb, and only retired from work for the Navy in the summer of 1918, very nearly the period of time to which I have alluded. Between the Crimean and the Egyptian Wars alone he witnessed or worked at the invention and use of the torpedo, the invention of the submarine mine, the use of long distance signalling, the advance of scientific gunnery, and the revolution in ship construction between the old three-decker "Algiers," and the battleship "Inflexible," a ship now thrown into the scrapheap, in comparison with "Nelson" and "Rodney" and other famous monsters of the sea. Since the Egyptian War up to 1918, the developments are too numerous to describe. No dream of the air, or wireless communications, or the spread of the turbine engine or the development of oil, or the submarine ship, engaged the practical mind of Sir Arthur Wilson in the Egyptian War, yet he lived to see them all commencing their careers.

Compare this with the considered opinion of Captain Washington, R.N., F.R.S., given before the Society on March 3rd, 1852, when he stated the following appreciation on the progress of Naval Architecture, and on the exhibits: "In the Mercantile Navy the magnificent ship, the Great Britain, constructed by the eminent builder, Patterson, of Bristol, claims the first place, both as an iron vessel and as a screw-propelled steamer. This noble ship, 317 feet long, with engines of 1,200 horse power, has repeatedly made the voyage across the Atlantic; and now that she has been repaired and strengthened, is again open to start on a similar voyage, in which it may be hoped she may meet with the success that her spirited owners deserve. In a country like England, where iron is so abundant, cheap and well adapted to various purposes, it was natural to use it instead of wood, and it has been largely substituted for timber in building ships. The advantages of iron vessels, when carefully built, consist, generally, in their durability, strength, capacity for stowage, economy and salubrity; but iron does not appear to be applicable for ships-of-war."

Verily a certain play, which many of you have seen, was well entitled "Milestones"; but though the gallant captain may have been too dogmatic about the use of iron and its derivatives, he at least had the spiritual sense of hope, and the practical sense of seeing the value of that Chinese proverb which Sir Robert Hadfield has so often reiterated: "He who owns the iron of the world rules the world," a proverb not unworthy of consideration at the present moment.

The lectures on the Exhibition of 1851, from which I have quoted, were inaugurated by the celebrated Master of Trinity, Dr. Whewell, in an address sprinkled with Latin quotations and allusions to Aristotle and Sophocles, Longinus and Homer, Ulysses and Calypso. Some of the aspirations of the period are still before us, some of them have been fulfilled, some have signally failed. I will

only call attention to a few types. Professor Solly, on vegetable substances, remarks: "With continued care and attention, and by persevering in the introduction of improved methods, a complete change will in time be effected in the deficiencies of East Indian cotton, so that ere long any quantity of sound and good cotton may be imported for the use of manufacturers, from British India. The cotton at present imported from the British colonies does not quite amount to a million pounds yearly. It is, however, rapidly increasing. The cotton of British Guiana is excellent, and some of that lately sent over from South Africa is also very promising. Considerable progress is also being made in the cultivation of cotton in the northern parts of Africa. . . . Mr. Mercer's new process for modifying its chemical and physical properties seems likely to produce very important alterations in the manufacture of cotton generally."

Mr. James Glaisher, F.R.S., announced the following conviction: "The high interest that science in its highest applications and developments of power commanded from the Illustrious Designer of the Exhibition leads to the reasonable expectation that more encouragement will be held out to those who are capable of adding to the number of truths on which such applications are founded, and in this view I am supported by a brother juror, Sir David Brewster, who writes: 'I am persuaded that the Exhibition will exercise the most salutary influence on this subject, in so far as it will turn the attention of the influential classes of society to the vast national importance of encouraging science and the arts by placing men who advance them in a better position than they have hitherto occupied in this country.'" Has that persuasion come true?

Another writer was too enthusiastic over a difficulty still with us when in writing of certain bricks he says that this simple means will place at the command of the working man "a certain degree almost of luxury, which tends to refine the mind, and substitutes a comfortable home for a miserable and barely efficient shelter from the elements, the ambitious and wise design of those who have of late actively promoted the improvement of the dwellings of the working classes."

The dominating Mr. Henry Cole was more within the mark when he said: "The beginning of the reform of our Patent Laws or laws for the recognition of the rights of intellectual labour, which I foresee may have great international results on industry, is due to the Exhibition." He was quite right. The Revised Patent Laws did result from the Exhibition of 1851, and I trust very sincerely that a subject in which I have taken great interest, a British Empire Patent, will be the result of the present Economic Conference and the Exhibition of 1924. The recent resolution of the Economic Conference seems only to go half-way towards that desirable result.

Following upon the Exhibition of 1851 there were very remarkable developments on which, though not due to the Exhibition, I think it may be said the Exhibition had weighty influence. At the very end of 1863, in a report on the Exhibition of 1862, the statement is made that "Never before in the history of man have the products of the mineral kingdom exercised within a brief period so momentous an influence on the fortunes of nations as that which in the last fourteen years has riveted the attention of the whole civilized world. If we look back only to the date of our first Universal Exhibition, we find that a series of changes has been brought about which, but for the potency of the effect produced by mineral substances, would have required decades of years, if not centuries, to accomplish. Coal, the great basis of manufacture and locomotion, has been extracted on a scale never before contemplated, and sought for and found in new countries and under new conditions with something like equal strides; it has also been made to yield a variety of products brought with unexampled rapidity into the applications of daily life. Iron and steel have been manufactured in masses and applied to purposes equally unknown in former times. Metals scarcely known except by name in 1851 have become the subjects of operations of commercial importance. And, lastly, the succession of gold discoveries in so many widely separated and enormous regions has led to the exploration and settlement of vast tracts by myriads of men, with a facility which was impossible before the extended use of iron and coal had smoothed the way for so gigantic an emigration."

Is it too much to prophecy that the principle involved in this statement will be the principle which the coming Exhibition may best keep in view and may best assist,

in ways and means of which many were unknown and undreamed of in 1863, namely, the abolition of distance?

No longer is the world divided into small states, with relatively little interest in their external dominions, but vast empires and great countries have competed for a hold over the more sparsely peopled lands or less energetic peoples, and divided the world—the British, French, American and Russian countries, and in lesser degree Germany, Italy and Holland. Western civilization has indeed seized the reins of the world, and with the complexity of life and trade which makes it almost impossible for countries to be self-sufficient, it has become a necessity to organize and utilize the less developed portions of the earth. Further, the more highly industrialized a country may become, the more dependant must it be on supplies brought from all parts of the world. The abolition of distance becomes a necessity of existence.

We are not saying now "What has the world got to offer?" but "What has the British Empire got to offer, not to the United Kingdom only, but by every country within the British Empire to every other country within the British Empire?"

In their summings up the lecturers of 1852 dilate on the extension of trade, the new processes, the application of science to industry, and the coming future developments; but the products of the British dominions are scarcely mentioned. In Mr. John Hollingshead's Concise History of the International Exhibition of 1862, he says that "In 1851 the colonies were, as a whole, almost unrepresented. The notice given was too short; the undertaking was hurried; the project was quite new, and not thoroughly understood; and, moreover, most of the colonies were scarcely in a position to go to much expense for contributions. The East India Company, however, made a noble display and some few of the British colonies a respectable appearance."

It was not till the Indian and Colonial Exhibition, and the Jubilee pageants of 1887 and 1897, that the nation began to awake, largely by these shows, to a better knowledge of the import of the British Empire; and how much has happened since to bring that knowledge home by practical facts? It is but fitting that some stock should be taken and education spread more widely than ever; to make us realize that the British Empire is not that which the German Treitschke called it, "A thing which is wholly a sham," but a living and growing entity, bound together in a manner different from any other known to history.

The aspirations and thought of that Empire may not be crystallized in any code. Some might characterise them as vague and indeterminate, but yet the immediate course of movement seems in some measure to be indicated by present waves of thought, and by the practical application of those thoughts, and it is within our province to consider whether they are reflected in this Exhibition. If I may select only three of the present movements, now being rapidly developed, they would be these: First, the extension of speedy communication; second, the extension of research into the history of man, of the world and of the universe; third, the determination to search for and reduce and cure disease among men, animals and plants. There might be added other movements, such as various applications of machinery, but these three great movements are engrossing great attention, and seem to progress, despite the hindrance of political and racial quarrels, despite the squabbles between capital and labour and social changes, with a certainty and speed which ignore the littleness of hindrance and convince mankind even against their will. And yet they may be changed, just as the ideas of 1851 were changed, by new discoveries and new ideals of which at present we have no ken.

Apart from new material, however, these three movements are quite capable of affecting or settling great matters, provided man pursues them with courage and judgment. The peopling of the world, the education and feeding of the world, are involved in the speedy communication, in such items as the turbine engine, broadcasting, telephony and wireless. Secondly, the theory of Einstein, the marvellous work of Rutherford, the digging of Evans, Carnarvon, and Howard Carter, and the American research in Mongolian fossils are but illustrations of the movement for research into the history of man, the world, and the universe. And thirdly, as to disease, nothing has been more remarkable than the range of interest taken in this subject, from cancer to the boll weevil, by scientists and the public at large. Almost as if answering to the demand the discoveries of science have been manifold; and if the

mere means of support were more forthcoming, those discoveries might be multiplied with increasing speed, but while we endow unemployment with hundreds of thousands of pounds, we cut off subventions for the bare maintenance of the institutes of science as if they were superfluous.

Of these three great movements to which I have alluded, apart from any surprises, the coming Exhibition will be a great exemplar, bringing them into better knowledge amongst the mass of the people, and also amongst the people of all our dominions. It has well been said by an American paper (The Christian Science Monitor): "This Exhibition may be regarded as a co-operative effort towards developing a greater commonwealth founded upon that confidence and goodwill which is manifesting itself among the British people in every part of the world." At the present time that is a great truth, and the pursuit of knowledge in these three movements must add to the co-operation, to the confidence and goodwill, thus alluded to.

All of them receive undoubted attention, and some in a manner quite new, I think, to exhibitions of this character. Thus there is to be a World Power conference, to consider the national and international adjustment of power. The discussions are billed to be on Power Resources, Power Development, Transport by Land, Air and Water, Power Applications in Agriculture, Industry and General Utility, and Economic and Financial Power. Following the example of Brussels, there is a section to illustrate the dangers of Tropical diseases and their prevention and cure, as well as demonstrations of plant and animal diseases. In special sections and in the general "lay-out" of the Exhibition these great movements are remarkably included in every one of the main sections, with their groups and classes. These sections are to be housed in buildings designed with harmonious intent, many of which may be deemed to be a triumph of architectural skill and taste, while the exhibits will be arranged in a manner from which the old show cases will be strangely absent. In the great Stadium pageants, more educative and striking than any that art has yet attempted, will show the evolution of British history. Films will preserve those pageants and, circulated through the land, bring home to every school more knowledge than teachers could ever give by word of mouth. The Stadium too will be used to illustrate the effects of massed music, in addition to many athletic contests, and on Empire Day for a solemn service, when King and peoples will together join in united hymn and prayer.

In most of the accounts of the Exhibition I have seen a great amount of space taken up in speaking of its size. Thus: "The Overseas Empire occupied only 60,000 sq. ft. at the Paris Exhibition of 1900, and even at the White City in 1908 no more than 160,000 sq. ft. At the British Empire Exhibition from 600,000 to 700,000 sq. ft. of space will have to be provided." Or, again: "Originally 120 acres, the site of the Exhibition has been extended to meet growing demands, and is now over 200 acres." Or, again: "The size of the Exhibition may be imagined when we say that the frontage of the two buildings which will house the Industrial Exhibits of the United Kingdom alone could extend from Charing Cross Railway Bridge to Westminster Bridge. Those erected by the Dominions, India and the Colonies will be on a similar magnificent scale." etc., etc., etc. Those of you who visit the Exhibition will doubtless find it as large as you desire it to be, without caring much as to the exact number of square feet which it contains, or the cost, but will pay more attention to the mass effect, and to the ease with which you will find the exhibits or departments which each person desires to see. Both of these results are claimed for the Exhibition.

The amusement part of the undertaking is also said to be going to be of a higher standard of excellence than has been attained at any previous exhibition, with musical and dramatic performances and, as it is curtly put, "the usual attractions appealing to all classes and all ages . . . in abundance." Not only that, but sport and athletic contests will draw tens of thousands whom "the usual attractions" might not influence. They, as well as the majority of visitors, will have to be supplied with food and drinks, so that catering, with all its ramifications, will be a business taxing ingenuity and skilled organization. Sir P. Cunliffe Owen started upon a line of attracting the public which he would scarcely recognize, and that one branch alone vividly illustrates the immense strides which have been made in the development and growth of Exhibitions.

Lastly, it is of no use talking about an

exhibition unless you can get there. Most exhibitions have left much to seek in this respect. This one will provide a very crucial test, and be an object lesson, it may be hoped, in what organization can effect. Apart from motors, tramways and buses, and provincial traffic, it is said that there are 126 stations in the London area from which the Exhibition may be reached in 18 minutes, and 120 City and suburban stations from which it can be reached without changing. The motor park seems rather small, but there are new main roads for motor traffic. If the immense numbers of people leaving in the final rush hours can be daily handled without hitch, a remarkable feat will have been accomplished. I hope there will be places at each station for lost children, and possibly for apprehended pickpockets!

In addition, within the Exhibition itself, internal railways and electric trolleys are to ease the disturbing factor of fatigue of the body, and a system of flood lighting in various tones of colour is designed to mitigate the fatigue of the eye. How such changes will affect complexions and dress remains to be seen. Light by day and light by night, light such as no other exhibition has ever had, coupled with a demonstration of "things electric" in every sense, should indeed make it, in the modest words of the *Electrical Review*, "an occasion to convince the world of many things."

One could dilate at infinite length on the details and other qualities, not to mention quantities, of this vast display, and doubtless that task will be gradually done, and, in fact must be done, by book, magazine and newspaper, for the continued education of our far-flung peoples. This Exhibition is not the last word. It is a stepping stone in the long line of previous shows, evolved from the changes in the world, the progress of commerce, science and art, and especially the united effort in a common cause of all the great nations and countries who will be here represented for comparison or emulation in one small space (if one may apologize to the eulogists of size), and who had never been joined before 1914 in one united concrete enterprise. It will be a milestone in the road of progress. Its effects may be manifold in many startling ways, concretely in science, industry and art, and mentally in impressions and knowledge. Those impressions will be as varied as the nations, races and minds of the millions by whom it will be visited, but to few will be denied all imaginative capacity, and it may be that at least there is one type of impression which may be common to all those many millions—possibility and hope. In that event the spirit of the Exhibition—the real thing that matters—will not vanish away, and be lost to memory, but will live and grow through the coming centuries, even when the passing troubles of the present day have become only incidents in an historical past.

The Chairman then presented the medals for Papers and Lectures given during the last session, as follows:—

Papers read at the Ordinary Meetings:—

Overingenieur Dr. Sigurd Smith (Charlottenlund, Denmark), "The Action of the Beater in Paper Making, with special reference to the Theory of the Fibrage and its application to Old and New Problems of Beater Design."

Major W. S. Tucker, R.E., D.Sc., "The Hot Wire Microphone and its Applications to Problems of Sound."

Edward Percy Stebbing, M.A., F.L.S., Professor of Forestry, University of Edinburgh, "The Forests of North Russia and their Economic Importance."

Sir William Mackenzie, K.B.E., K.C., "Industrial Arbitration."

Papers read in the Indian Section:—

The Earl of Ronaldshay, G.C.I.E., late Governor of Bengal, "A Clash of Ideals as a Source of Indian Unrest."

Geoffrey Rothe Clarke, C.S.I., O.B.E., I.C.S., Director-General, Posts and Telegraphs, India, "Postal and Telegraph Work in India."

Papers read at Joint Meetings of the Indian and Dominions and Colonies Sections:—

Lieut.-Colonel Sir Leonard Rogers, C.I.E., F.R.S., F.R.C.P., F.R.C.S., Physician and Lecturer, London School of Tropical Medicine, "Recent Advances towards the Solution of the Leprosy Problem."

Sir Richard A. S. Redmayne, K.C.B., M.Sc., M.Inst.C.E., M.I.M.E., F.G.S., "A Review of the Base Metal Industry, with Special Reference to the Resources of the British Empire."

DISCUSSION.

Mr. Alan A. Campbell Swinton, F.R.S., said he was sure the audience would not wish to disperse without according a very hearty vote of thanks to Lord Askwith for his admirable and eloquent address. Lord Askwith had touched on many subjects, and the address must have taken a great amount of time and trouble to prepare. It was a very complete paper dealing with all aspects of the subject. He would only speak with regard to two of them. Lord Askwith had said, quoting somebody else, that the ordinary manufacturer looked upon Exhibitions not altogether with pleasure. Among other things, he (the speaker) happened to be a manufacturer—at least he was a director of several large manufacturing concerns—and the attitude of manufacturers towards Exhibitions was, he thought, as follows. Probably new undertakings welcomed Exhibitions because they were a method by which those undertakings became known by exhibiting at them, but old-established manufacturers were inclined to look upon Exhibitions more or less with dislike. They, however, recognised it was necessary that they should exhibit at them, as they could not afford to be left out.

The other matter to which he would like to refer was the great want in London of a suitable building for Exhibitions—not big Exhibitions such as that which was going to be held next year at Wembley, but ordinary kinds of Exhibitions like the Motor Show. Every time he went to Paris and saw the admirable arrangements which existed there in the Grand Palais, he always wished there was a similar building in the heart of London. The White City and Olympia were all very well in their way, but they were far off. His thoughts always went back to those very delightful Exhibitions—he thought the first one was the Health Exhibition, which was followed by the Fisheries Exhibition and lastly, and best of all, by the Inventions Exhibition—which took place in the '80's, and which were held on the ground now occupied by the Natural History Museum and the Science Museum, and where there were delightful gardens, to which everybody could get from the West End of London in a few minutes. He had always thought that those Exhibitions had been most charming—perhaps because at that time he was rather younger than he was at the moment!

Sir Philip Magnus, Bt., in seconding the motion said he ventured to think that few persons could have been found with so characteristic a knowledge of what Exhibitions had been and what Exhibitions should be as Lord Askwith, who held the position of Head of the Exhibitions Committee of the Special Department of the Board of Trade, and who had given time and thought and years of service in connexion with matters appertaining to Exhibitions. Lord Askwith had given a most interesting history of International Exhibitions from the year 1851 to the present time, and had pointed out the several principles on which Exhibitions should be conducted, and had carefully explained—although perhaps the audience had not all fully understood it—the difference between vertical and horizontal Exhibitions. Lord Askwith had said that few persons could carry back their memories to the Exhibition of 1851. He was one. He remembered visiting that Exhibition on more than one occasion but he could not say from those visits that he could give anything like the full particulars of it which had been given by Lord Askwith. He could not even remember whether it was vertical or horizontal! He believed it was both. He was quite certain, however, that it must have been carried out with due preparation and with proper organisation, and that it had aroused the interest of all persons visiting it. The Exhibition of 1851 had been attended with results which possibly had not followed from any other Exhibition. The public owed to the Exhibition of 1851 the Art Museum at South Kensington; they owed to it the Science Museum which had recently been erected; the Imperial College of Science and Technology; the Natural History Museum, and many other buildings and institutions for the promotion of those objects which the Prince Consort had at heart. It was pleasant to realise that the organisation of the Exhibition of 1851 had been very largely effected by the Royal Society of Arts. Lord Askwith had not only stated what were the chief features of all the Exhibitions to which he had referred, but he had indicated very clearly with almost prophetic vision some of the principal results which might be expected to follow from the Exhibition of 1924. All he, personally, could hope was that the results of the Exhibition of 1924—which, after the description given by Lord Askwith, everybody would be most desirous of visiting—might be as great and as lasting, and as conducive to the advancement of civilisation as the Exhibition of 1851.

The vote of thanks was then put and carried unanimously.

Lord Askwith, in acknowledging the vote, said he was especially glad to have unearthed a very learned man who had visited the Exhibition of 1851, and who remembered nothing about it, but who recognised the great changes and results which had come from it. He trusted that Sir Philip Magnus would go to Wembley, would try to hunt about in his memory in order to compare the Exhibition of 1924 with the Exhibition of 1851, and that next year he would give the Society the result of his conclusions.

The proceedings then terminated.

NOTES ON BOOKS.

Crystallisation of Metals. By Colonel N. Y. Belaiew, C.B. London: University of London Press, Ltd. 7*s.* 6*d.* net.

Colonel Belaiew's research on the crystalline forms assumed by metals, and of structures derived

from crystalline forms are now presented to the English reader in a matured and revised form for the first time. The Author delivered a special course of lectures on the subject at the invitation of the University of London, and the present work is the text of the lectures, together with many illustrations in the letter-press, and a series of 21 photographic plates.

Beginning with a concise but profound study of the nature of a crystal, he emphasises the cleavage and space-lattice aspects as criteria for distinguishing between a vitreous mass and crystal; the influence of vectorial force in crystallisation is then touched on. Apart from the usual six systems as set forth in the text books, we have (pp. 35-88) a comprehensive study of dendritic groupings, skeleton forms and interlocked dendrites; this portion including the study of the Wiedmanstätten figures in meteoric iron and their parallels in artificial iron.

Structural equilibrium in solids is touched upon from the point of view that there is latent energy in an extended or out-spread form, whether by dendritic growths, lamellar condition, or broadly speaking any irregular form which arises during a dynamic stage, such as fusion and a resulting crystallisation; this energy constantly straining to reduce the total surface of the crystal or its complement, and to force it to assume or approximate to that form which has the minimum area, to wit, the sphere (p. 125). If the crystals are small, this spherodisation may be easier and more complete than if large. Thus this second-stage action of surface tension is studied and illustrated in wonderful and lucid detail, so charming and manifold, that description in a short notice is out of the question: but this aspect culminates in a unique but short account of the Damascene process and the working manner of an aged smith whom our author's old master and venerated tutor (p. 18), Tschernoff met at Zlatoust (p. 139); a smith, who by gentle heatings and subsequent forgings, under occasional tests by scrubbing and etching, knew how to spherodise thoroughly all the cementite particles.

This remarkable work will interest the student of physics, instruct and give thought to the iron-master, and the illustrations, which culminate in plate XXI. Damascene blades, may give suggestions as to the near kinship of fine or spiritual art with technical fitness.

The London City Churches: their Use, their Preservation and their Extended Use. Compiled and issued by the London Society. London: T. Fisher Unwin, Ltd. 1*s*.

A great deal of public interest was recently roused in the controversy which was carried on for some time in the press and elsewhere, over the problem of the London City Churches. People with an eye for the historic and the beautiful were aghast at the proposals for the demolition of some of Wren's masterpieces; others, intent upon the utilitarian, were equally shocked by the spectacle of valuable sites encumbered by buildings which were hardly ever used. In view of these divergent opinions it was a happy thought on the part of the London Society to issue this booklet which contains in the first place historic notes by the well-known antiquary, Dr. Philip Norman, on each of the forty-five churches; secondly, a tabular list of the churches and their present uses, and finally some suggestions for extending these uses, by the Rev. Arthur G. B. West, Rector of St. Dunstan's in the East. The great virtue of the pamphlet is that it gives one, in very brief space, a clear idea of the historic and architectural value of the churches, and of the extent to which they are at present being used. In several of the buildings much-needed rest-rooms are provided for work-girls, who, in order to take advantage of cheap workmen's tickets, have to come to the City long before their work begins; in others lectures are given, or organ recitals, or rooms are provided for boys' and girls' clubs; but when one looks through the tabular list of the churches one cannot help feeling that a great deal more use ought to be made of them before they can justify the continuance of their present existence.

Electrical Measuring Instruments and Supply Meters. By D. J. Bolton. London: Chapman and Hall, Ltd. 1923. 12*s*. 6*d*. net.

Line Charts for Engineers. By W. N. Rose. London: Chapman & Hall, Ltd. 1923. 6*s*. net.

These are volumes for the engineer's bookshelf, and they form part of Messrs. Chapman & Hall's "Directly Useful Technical Series," a series in which ready reference with practical instruction is the leading concept; while theoretical comments references or proofs are added when required.

Mr. Bolton's book of 328 pages gives a good insight into the use and nature of the whole range of present day electrical measuring devices. In illustration of its full detail, we may mention the double-sided plate which is inset between p. 132 and p. 133, this plate showing a single phase induction supply meter, a three-phase arrangement, maximum demand fittings, pendulum escapement for Aron meter, Aron meter with maximum demand fittings, and the mechanism for allowing prepayment.

In a concluding section modern electric pyrometry is treated of in a notably thorough manner; resistance method, the thermo-couple method and the many aspects of the radiation methods being considered. The optical aspects, as developed by Le Chatelier, Morse, Tinsley and others are considered at some length, the great advantage being the facility of taking a series of rapid measurements as to different parts of a furnace.

Mr. Rose in his treatise gives the engineer practical instructions as to making calculations instantly by means of line charts, the instructions for making the charts being lucid and detailed. One special advantage of the chart method is the elimination of casual or oversight errors to

which calculations must always be liable. Naturally the accuracy of chart results depends on the care with which the charts are made, and also on the size of the chart. We may perhaps give a hint as to the convenience of flat-rolled sheets of zinc or aluminium about one-tenth of an inch thick and scribed with a fine steel point, then filled in with black. Chart No. 47 for powers and roots, is a good example of a moderately complex chart which is easy to construct or to use; while No. 44, a chart for Unwin's welded steel flue formula is an example of many charts quite special to engineering practice.

Mr. Rose deserves high praise for the thoroughly practical way in which he presents his subject to the reader, and as an illustration of his thoughtfulness we may mention Nos. 21 and 22 charts for proportion, each suited to a slightly different mentality.

We may conclude by remarking that both the books under notice can be unreservedly recommended.

THE CANTON FEATHER INDUSTRY.

Feathers of two kinds—those used for filling cushions, pillows and mattresses and those classed as ornamental or fancy feathers and used for hats and dresses—have been exported from China for many years. In the Canton district, writes the United States Vice-Consul at Canton, feathers of the ordinary type are gathered up-country by pedlers who go from village to village collecting small quantities of duck, fowl, and other kinds of feathers.

What the pedlers gather is passed on to larger dealers, who in turn ship the feathers by junk to Canton and Fatshan. At these two places the feathers are half sorted and sold to the eight or ten large Chinese feather merchants who supply the foreign commission houses.

There are 25 or 30 grades of these feathers, all of which are sold by the picul of 133⅓ pounds. The chief demand in Europe comes from France and the Scandinavian countries, where feathers for use in making feather beds are in favour. Feathers sorted for Europe may contain 30 per cent. dirt. A better grade is demanded for the American market, the maximum of dirt being fixed at 15 per cent.

When the feathers reach the foreign commission houses at Canton, the dirt and the long feathers are removed by hand. Some firms use an electric blowing machine to test samples before packing. This machine removes the dust so that the feathers may be inspected more closely. When ready for export, the feathers are packed either in loose bales of 1½ piculs or in hydraulic pressed bales of 3 piculs.

There are many kinds of ornamental or fancy feathers exported from Canton, the most popular of which are the silver and golden pheasant, numidae, and peacock feathers. In 1919, 1,542 U.S. dollars' worth of ornamental feathers were exported from Canton in 1919, 3,171 dollars' worth in 1920, and 3,920 dollars' worth in 1921.

THE BARBADOS ALOE INDUSTRY.

At a recent meeting of the Barbados Agricultural Society, Mr. Bourne, Acting Director of Agriculture, stated that he believed it would be profitable to grow aloes again in that island for the American market. In the opinion of Mr. Bourne, there are about 3,000 acres of waste land along the coast in Christ Church, St. Lucy, St. Philip, St. John, and St. Joseph Parishes suitable for the growth of the plant. Aloes were raised in Barbados for commercial purposes as far back as 1657, and the industry was kept up until the early part of the present century. It was abandoned then, writes the United States Consul at Bridgetown, because Curacao and other Dutch Islands had begun growing aloes, which resulted in over-production and a consequent drop in price.

The aloe plant grows to an average height of 2 feet, with a number of leaves which are about 4 inches broad, three-quarters of an inch thick, and 18 inches long. The commercial value of the aloes lies in the juice contained in these leaves. The leaves are ripe for cutting at the end of the first year and bear every year for six years, after which the yield falls off. The average yield for full-grown plants is about 500 pounds per acre. When the plant begins to bloom, which is in February and March, the leaves are cut off and the juice is collected in gourds, boiled, and allowed to cool.

Aloes are planted in rows about 2 feet apart, the distance between each plant being one foot. All that is required in the cultivation of aloes is to manure the soil well before planting and then to keep the land weeded. One advantage of this crop is that other crops, such as okra, guinea corn, and yam, can be grown between the rows; also the gourd vine, the gourds of which are afterwards used to contain the juice of the aloes.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock:—

NOVEMBER 28.—SIR HENRY JOHN GAUVAIN, M.A., M.D., M.Ch., Medical Superintendent of the Lord Mayor Treloar Cripples Hospital, "The Effect of Sun, Sea and Open-air in the Treatment of Disease." LORD DAWSON OF PENN, G.C.V.O., K.C.M.G., M.D., F.R.C.P., will preside.

DECEMBER 5.—ARTHUR WILLIAM HILL, M.A., Sc.D., F.R.S., F.L.S., Director of the Royal Botanic Gardens, Kew, "The Work of the Royal Botanic Gardens, Kew." CHARLES ALBERT SEWARD, M.A., F.R.S., F.G.S., F.L.S., Professor of Botany in the University of Cambridge, will preside.

DECEMBER 12.—SIR FRANK BAINES, C.B.E., M.V.O., Director of Works, H.M. Office of Works, "The Preservation of

Historic Buildings and Ancient Monuments." Sir Aston Webb, K.C.V.O., C.B., P.R.A., will preside.

Indian Section.

Friday afternoons, at 4.30 o'clock.

December 7.—William Foster, C.I.E., Historiographer, India Office, "The Archives of the Honourable East India Company." (Sir George Birdwood Memorial Lecture.) The Rt. Hon. Viscount Peel, G.B.E., Secretary of State for India, will preside.

Dominions and Colonies Section.

Tuesday afternoon, at 4.30 o'clock.

November 27.—Viscount Burnham, C.H., LL.D., D.Litt., M.A., "The West Indies." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

December 17 (Monday.)—Wm. C. Noxon, Agent-General for Ontario, "Settlement within the Empire."

Papers to be Read after Christmas.

G. Albert Smith, "Cinematography in Natural Colours—further developments" (with illustrations—scenes from H.R.H. The Prince of Wales's Tour in India).

Iyemasa Tokugawa, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Sir Richard Arthur Surtees Paget, Bt., "Fused Silica and its use as a Refractory Material."

H. Maxwell Lefroy, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle."

Percival James Burgess, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber."

Charles S. Myers, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation."

T. Thorne Baker, "Photography in Industry, Science and Medicine."

Sir Richard M. Dane, K.C.I.E., Commissioner North India, Salt Revenue, 1898-1907; Foreign Chief Inspector, Salt Revenue, China, 1913-18, "Salt Manufacture in India and China."

Brigadier-General Henry Alfred Young, C.I.E., C.B.E., late R.A., Director of Ordnance Factories, India, 1917-21, "The Indian Ordnance Factories."

Jocelyn F. Thorpe, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Colonel H. L. Crosthwait, C.I.E., R.E., retd., late Superintendent, Survey of India, "The Survey of India." Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., Rector, Imperial College of Science and Technology, will preside.

Bhupendra Nath Basu, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

F. W. Walker, "The Commercial Future of the Backward Races, with Special Reference to Papua." Sir George R. Le Hunte, G.C.M.G., will preside.

Indian Section.

Friday afternoons, at 4.30 o'clock.

January 4, 18, February 15, March 21, May 2.

Dominions and Colonies Section.

Tuesday afternoons, at 4.30 o'clock.

February 5, March 4, April 1, May 27.

Cantor Lectures.

Monday evenings, at 8 o'clock.

Aldred F. Barker, M.Sc., Professor of Textile Industries, The University, Leeds, "Recent Progress in the Wool Industries." Two Lectures. December 3, 10.

Eric Keightley Rideal, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University Cambridge, "Colloid Chemistry." Three Lectures. January 21, 28; February 4.

Edward Victor Evans, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

Cobb Lectures.

Monday evenings, at 8 o'clock.

Dr. T. Slater Price, Director of Research, British Photographic Research

Association, "Certain Fundamental Problems in Photography." Three Lectures March 24, 31; April 7.

DR. MANN JUVENILE LECTURES.

(*Special tickets are required for these Lectures*).

Wednesday afternoons, at 3 o'clock.

DR. WILLIAM ARTHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology. "Fire and Explosions." Two Lectures. January 2, 9. The Lectures will be fully illustrated with experiments.

MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, "Among the Selkirk Mountains of Canada (with ice-axe and camera)." One Lecture. January 16. The Lecture will be fully illustrated with hand-painted lantern slides.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, NOVEMBER 26..Health, People's League of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Dr. Saleeby, "Sunlight and Health." (Lecture IV.)

University of London, King's College for Women, 61, Campden Hill Road, W., 5 p.m. Prof. V. H. Mottram, "Newer Aspects of Nutrition." (Lecture VIII.)

Swiney Lecture, King's College, Strand, W.C., 5.30 p.m. Dr. W. T. Gordon, "Gem Minerals and their Uses in Art and Industry." (Lecture IV., Diamond.)

Faraday Society, at the Institution of Electrical Engineers, Victoria Embankment, W.C. Conference on Electrode Reactions and Equilibria, 3 p.m., Part I. 1. Dr. E. K. Rideal, Introductory Address—"The Mechanism of the Reversible Electrode". 2. Prof. E. Billmann, "Oxidation and Reduction Potentials of Organic Compounds." 3. Dr. J. Heyrovsky, "The Process at the Mercury-dropping Cathode. Part I.: The Deposition of Metals." 4. Prof. A. W. Porter, "Note on the Standardisation of the Sign of the Potential." 5. Dr. J. N. Pring, "The Determination of Affinity Constants by the Hydrogen and Quinhydrone Electrodes." 6. Prof. E. Baur, "Electrode-Potentials in Non-Aqueous Solutions." 7. M Shikata, "Concentration Cells and Electrolysis of Sodium Ethoxide Solutions." 8 Mr. J. A. V. Butler, "Studies in Heterogeneous Equilibrium" 5.30. Part II., "Irreversible Electrode Phenomena." 1 Prof. A. J. Allmand and Mr. H. J. T. Ellingham, "Introductory Address." 2. Prof. A. Smits, "Electromotive Equilibrium and Polarisation." 3. Mr. N. V. S. Knibbs, "The Gas Film Theory of Overvoltage." 4. Mr. U. R. Evans, "The Influence of Obstructive Films in Anodic Processes."

TUESDAY, NOVEMBER 27..University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. W. J. Perry, "The Pan Pacific Congress."

At King's College, Strand, W.C., Mr. E. F. Jacob, "Some Popular Misreadings of Mediæval History" (Lecture I.). 5.30 p.m., Miss Hilda Oakeley, "The Roots of Early Greek Philosophy" (Lecture I.). 5.30 p.m. Prof. H. C. H. Carpenter, "Metallic Crystals and their Properties" (Lecture I.).

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Captain C. H. Armitage, "The Gambia, our oldest West African Colony."

Anthropological Institute, at the Royal Society, Burlington House, Piccadilly, W., 8.15 p.m. Dr. E. H. Hunt, "Hyderabad Cairn Burials and their Significance."

WEDNESDAY, NOVEMBER 28..University of London, University College, Gower Street, W.C., 5.30 p.m. Dr. P. Harting, "Vondel's Lucifer and Milton's Paradise Lost."

Swiney Lectures, King's College, Strand, W.C., 5.30 p.m. Dr. W. T. Gordon "Gem Minerals and their uses in Art and Industry. (Lecture V., Corundum.)"

Automobile Engineers, Milton Hall, Deansgate, Manchester, Mr. L. Murphy, "The Misuse of the Internal Combustion Engine and Suggestions for its more Efficient Application."

Microscopical Society, 20, Hanover Square, W., 7 p.m. 1. Mr. C. Beck, "A New Projection Microscope for measuring Fine Wires and Fabrics to 1-50,000th Inch. 2. Messrs. Adam Hilger, "Dr. Müller's X-Ray Spectrograph for the Examination of Sub-Microscopic Crystalline Structures." 3. Mr. J. E. Barnard, "The Characteristics of a Microscope for general and special purposes. The Tests for Mechanical Efficiency that should be satisfied." 4. Dr. S. H. Browning, "The Application of the Microscope to Industrial Diseases." 5. Mr. C. A. Newton, "The Microscope in the Examination of Condensed Milk."

Japan Society, 22, Russell Square, W.C., 5 p.m., Commander O. T. Tuck, "Some Comic Mediæval Plays."

THURSDAY, NOVEMBER 29..Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Sqdrn.-Ldr. Maycock, "Airmanship at Sea."

University of London, University College, Gower Street, W.C., 5.30 p.m. Sir William Collins, "The Life and Doctrine of Sir Edwin Chadwick"

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr H. G. Williams, "Foreign Exchange: its Effect on Industry and Cost of Living"

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Linnean Society, Burlington House, Piccadilly, W., 5 p.m.

Electrical Engineers, Victoria Embankment, W.C., 6 p.m. (Joint Meeting with the Physical Society.) Discussion on "Loud Speaking Telephones."

Mining Engineers, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 11 a.m. Annual General Meeting. 1 Prof. R. W. Dron, "Hydraulic Stowage at the Dalzell and Broomside Collieries" 2. Prof. K. N. Moss, "Some Effects of High Air-Temperatures upon the Miner." 3. Mr. T. D. Jones, "Strata Temperatures in South Wales, including Pembrokeshire." 4. Mr. G. Coles, "The Specific Heat of Coal." 5. Sir William Ellis, "The Position of Mechanical Engineering in Colliery Operations."

London County Council, Geffrye Museum, Kingsland Road, E., 7.30 p.m. Mr. H. A. Tipping, "House Equipment under Elizabeth."

FRIDAY, NOVEMBER 30..Aeronautical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m. Mr. A. H. G. Fokker, "The Result of Twelve Years' Welded Tube Construction and the Development of Cantilever Wings."

University of London, at the London School of Economics, Houghton Street, W.C., 5 p.m. Prof. S. E. Morison, "The Origin of the Monroe Doctrine."

Swiney Lecture, King's College, Strand, 5.30 p.m. Dr. W. T. Gordon, "Gem Minerals and their Uses in Art and Industry." (Lecture VI.)

Junior Engineers, Institution of, 39, Victoria Street, S.W., 7.30 p.m. Mr. S. C. Saunders, "Notes on Designs of Paraffin Motors."

Mechanical Engineers, Storey's Gate, Westminster, S.W., 6 p.m. Prof. A. L. Mellanby, "Clyde Marine Oil Engines."

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FRIDAY, NOVEMBER 30, 1923.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2).

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 3rd, at 8 p.m. (Cantor Lecture.) ALDRED F. BARKER, M.Sc., Professor of Textile Industries, The University, Leeds, "Recent Progress in the Wool Industries." (Lecture I.)

WEDNESDAY, DECEMBER 5th, at 8 p.m. (Ordinary Meeting.) ARTHUR WILLIAM HILL, M.A., Sc.D., F.R.S., F.L.S., Director of the Royal Botanic Gardens, Kew, "The Work of the Royal Botanic Gardens, Kew." CHARLES ALBERT SEWARD, M.A., F.R.S., F.G.S., F.L.S., Professor of Botany in the University of Cambridge, will preside.

FRIDAY, DECEMBER 7th, at 4.30 p.m. (Indian Section.) WILLIAM FOSTER, C.I.E., Historiographer, India Office, "The Archives of the Honourable East India Company." (Sir George Birdwood Memorial Lecture.) THE RT. HON. VISCOUNT PEEL, G.B.E., Secretary of State for India, will preside.

CANTOR LECTURES.

On MONDAY, NOVEMBER 19th, 1923, MR. SAMUEL HENRY DAVIES, M.Sc., F.I.C., delivered the second and final lecture of his course on "The Cultivation of Cocoa in British Tropical Colonies."

On the motion of the Chairman, a vote of thanks was accorded to Mr. Davies for his interesting course.

The lectures will be published in the *Journal* during the Christmas recess.

SECOND ORDINARY MEETING.

WEDNESDAY, NOVEMBER 21st, 1923, MR. BERNARD RACKHAM, of the Victoria and Albert Museum, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Auckland, George Frederick, London.
Elwell, C. F., London.
Harding, William, Loughborough.
Hodgkinson, Thomas Walter, Purley, Surrey.
Hoyer, Anton Gotfred, Durban, S. Africa.
Joughin, Walter James, London
Levine, Professor Victor E., Ph.D., Omaha, U.S.A.
Lloyd, William Henry, Twickenham.
McEwen, Alfred, New York City, U.S.A.
Medlicott, Samuel Thomas, London.
Sleigh, Arthur Crofton, London.
Trusler, William Thomas, Enfield.
Williams, Samuel Powell, Bradford.

The candidates proposed at the Opening Meeting, on November 7th, of whom a list was published in the *Journal* of November 16th (pages 899-900), were duly elected Fellows of the Society.

A paper on "Forgeries of Ancient Stained Glass," was read by Mr. J. A. Knowles.

The paper and discussion will be published in a subsequent number of the *Journal*.

MANN JUVENILE LECTURES.

Under the Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 2nd and 9th January, 1924, at 3 p.m., by DR. WILLIAM ARTHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology, on "Fire and Explosions." The lectures will be fully illustrated with experiments.

A lecture will also be given on Wednesday, January 16th, at 3 p.m., by MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, entitled "Among the Selkirk Mountains of Canada (with ice-axe and camera)." The lecture will be fully illustrated with hand-painted lantern slides.

Special tickets are required for these two sets of lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once stating for which lectures they desire tickets.

PROCEEDINGS OF THE SOCIETY.

EXTRA MEETING.

WEDNESDAY, OCTOBER 3RD, 1923.

MR. GEORGE E. BROWN, F.I.C. (Editor of the "British Journal of Photography") in the Chair.

THE CHAIRMAN said that it was hardly necessary for him to introduce Dr. Mees to a Royal Society of Arts audience. They had listened to Dr. Mees in that room both before and after he became Director of the Eastman Research Laboratories at Rochester, U.S.A. They were very fortunate in that circumstances had made it possible for Dr. Mees to be again in this country for a few months.

The Paper read was :--

AMATEUR CINEMATOGRAPHY.

By C. E. K. MEES, D.Sc.,
Director of Research and Development, Eastman Kodak Company.

Amateurs have played a great part in the development of photography. The early workers in photography were naturally amateurs, though the first successful process, that of Daguerre, was utilized chiefly for making portraits and was the process first used by professional photographers. While Daguerre's process was being exploited, however, Fox Talbot discovered his process in which a negative was made and then printed, the practice followed at the present time, and in which the exposure, insufficient to produce a visible image, was followed by development to obtain a negative of sufficient strength for printing. Talbot, in fact, laid the foundations for our modern systems of photography. Scott Archer, the inventor of the wet collodion process, which followed the calotype process of Fox Talbot, and Maddox, who made the first gelatine emulsion, were both amateurs, and all the early work on dry plates was done by amateurs until about 1880, when the manufacture of dry plates on a commercial scale was fully established.

Important as was the work of amateurs, however, the possibilities of amateur photography were necessarily limited by the very cumbersome equipment which was required for the wet plate process, and even when dry plates became available, the portability of apparatus and the simplicity of photography were very far from their present level. Marked as has been the improvement in apparatus for the utilization of dry plates, the greatest step in the making of photography available to everybody was the development of the film camera.

The causes that restricted the use of photography by amateurs have operated to limit the use of motion picture photography by other than professional photographers. The apparatus required is very heavy and cumbersome; the standard motion picture camera, tripod, and magazines form a heavy load for one man, and, in addition the cost of the film is very great. The cost of making a negative and projecting the picture upon the screen is approximately sevenpence for each foot of film which in projection lasts one second on the screen.

Motion pictures are obtained by making a series of photographs of the object upon a long strip of film, each picture being a representation of the object at that particular moment. Sixteen of these pictures are taken every second, and when they are projected upon the screen, the different phases of movement blend together and give the appearance of motion. The film is held stationary while the picture is taken or projected and then is moved forward very quickly to a new position and is held still again so that sixteen times a second the film is moved forward, and sixteen times a second it must be stopped. This movement is accomplished by what is called the intermittent mechanism in the camera or projector, the film being moved by claws which catch in the perforations, pull it down into its new position by the height of one picture, and then come out of the perforations again, leaving the film motionless, until, as the movement of the mechanism continues, they re-engage and pull the film down again. In projectors a sprocket with teeth on it is sometimes moved intermittently to pull the film down instead of claws, which engage intermittently in the perforations.

The whole system of amateur motion picture photography which has been worked out by the Kodak company is founded on a film smaller than that used in the standard camera and on a new process used in finishing it, but of almost equal importance is the design of the apparatus in which the film must be used.

The camera is, on the whole, of standard type. It resembles, in fact, a standard motion picture camera of the highest grade, but in amateur size. No attempt has been made to cheapen the camera by the omission of any necessary feature or by any undue

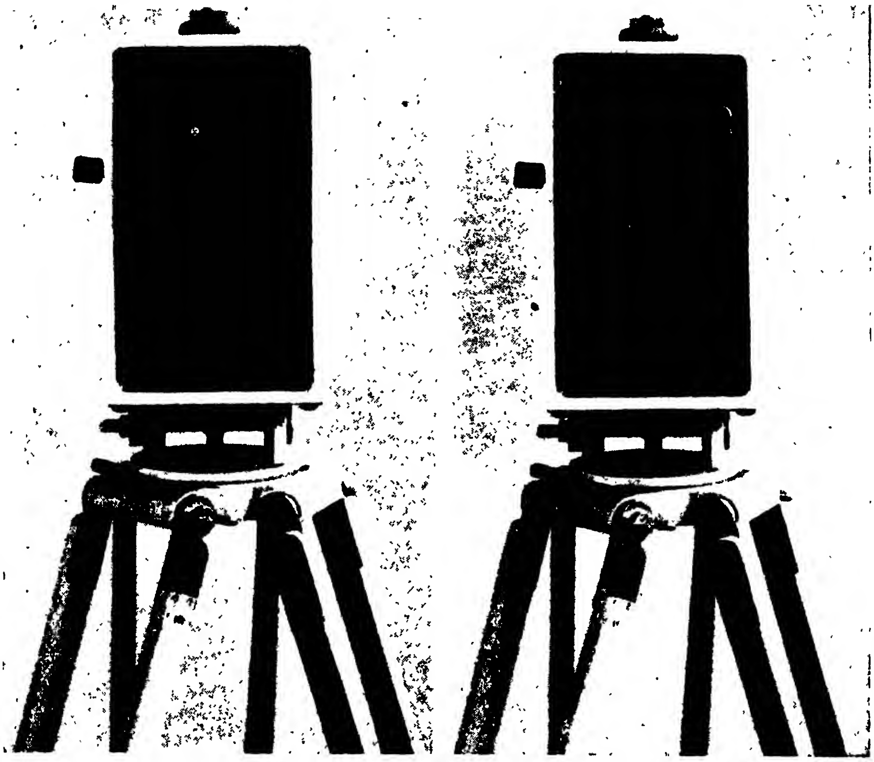

FIG. 1.—Front of the Cine Kodak.

simplification. The object was to produce an instrument which would take pictures equal in every respect to those which the professional could obtain. The weight of the camera loaded is eight pounds and of the tripod with its special head eight pounds, so that the camera ready for use weighs sixteen pounds. The lens is an anastigmat working at f 3.5, which enables photographs to be taken under difficult conditions of light. The finder is just above the lens (Fig. 1) and by an attachment changes the position of its image as the lens is focused, thus always showing the image through the centre of the field. The lens has a focusing lever carried through to the back which can be set for any distance from infinity to 4 feet. The diaphragm control is in the left hand corner and can thus be read easily. In the centre of the back is the footage indicator which shows the number of feet of film which have been used (Fig. 2). The crank is put out of the way into a recess when not required (Fig. 3). It is turned normally twice a second, taking pictures at the standard rate of sixteen pictures a second. The mechanism is of the standard motion picture type (Fig. 4), the film being pulled down by means of a claw operated by a cam mechanism.

In order to load the camera, the film spool, (Fig. 5) has its outer cover removed and is then placed on the upper spindle provided for it. To the film there is attached a paper leader of the same width as the film and perforated in the same way. Two feet of this are pulled out and are threaded over the sprocket of the camera on to which it is held by the presser plate, down through the gate, where the claws engage in the perforation, a loop being formed above the gate as is indicated on the camera mechanism, through another loop, which is also indicated, back under the sprocket, and thence to the bottom spool in which the end of the paper is inserted and a few turns made to ensure everything being right. The inner cover is then removed from the spool, the film being protected for a few seconds only by the paper leader. The door is placed on the camera, the footage indicator at the back of the camera is then set to 96 (indicated by a star) and the four remaining feet of red

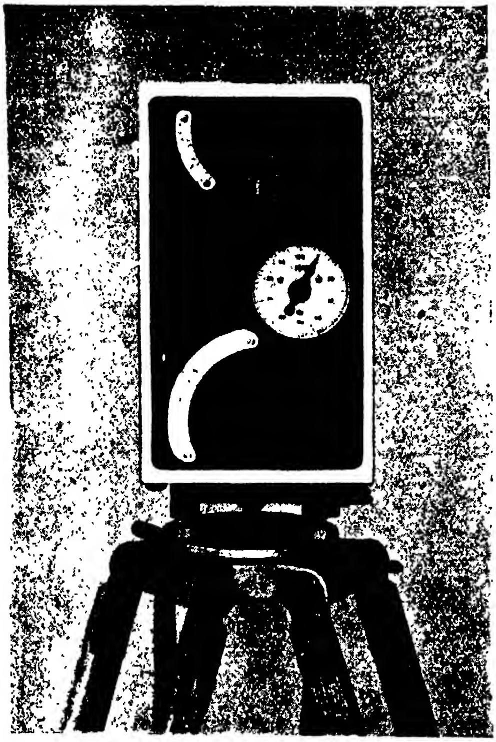

FIG. 2.—Back of the Cine Kodak.

paper leader wound off. The indicator then points to zero, and the camera is ready for use loaded with 100 feet of film. After all the film has been exposed, cranking is continued for six more feet, thus winding up another paper leader on to the exposed film. The camera door can then be opened, the covers put on the spool of exposed film, and the spool removed and sent to the Kodak Company for development.

The camera is used on a special tripod, made to be as light and yet as rigid as possible, the tripod head being made to rotate and to move in a vertical direction for the convenience of the operator, (Fig. 6). It is not intended that the tripod head should be used to produce panoramic pictures by rotating while the camera is being cranked. It is extremely difficult to do this smoothly, and the result obtained rarely gives a pleasing impression when projected. A rotating head is necessary to enable the camera to be moved in direction rapidly in order to follow objects in the field. After the film has been developed, the positive is ready for projection.

The projector, which is called the "Kodascope," is, like the camera, a standard projector of the highest grade with such

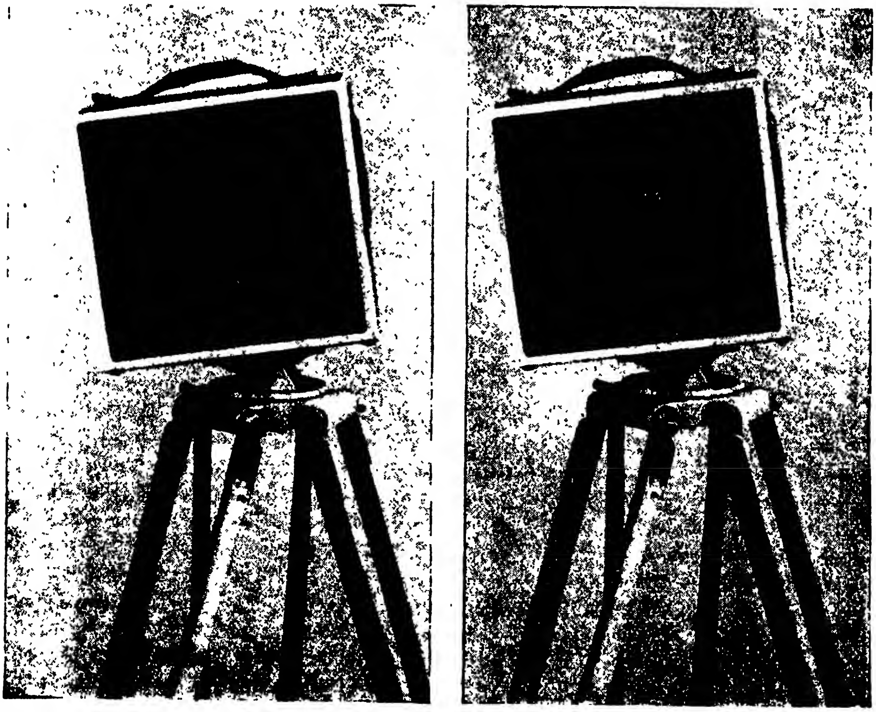

FIG. 3.—Crank side of the Cine Kodak.

FIG. 4.—Mechanism with the door removed—with film in position for exposing.

FIG. 5.—Film Spool.

changes as are necessary to make it suitable for use by amateurs and for the small film (Fig. 7). The mechanism is of the same claw and cam type as the camera. The film, which is usually assembled in 400 foot reels which are equivalent to 1000 feet standard reels and last for 16 minutes on the screen, is placed on the upper shaft and the film is threaded on to an upper sprocket which feeds the film in a loop to the gate, then through the lower sprocket to the take up reel, which is placed on the bottom shaft. The Kodascope is driven by a motor, and light is supplied by a lamp through a condenser which is attached just behind the gate. The lens is of very large aperture, specially designed and made, and has a focusing mechanism of a convenient type. This large aperture lens and efficient condenser system give a bright image on a screen with a small lamp, and for home use the apparatus is arranged to give a satisfactorily bright screen of 4½ feet in width, the two standard sizes of screens for home or class-room use being 30″ × 40″, which is large enough for the ordinary room, and 40″ × 54″, which is preferable for very large rooms or class-rooms. By changing the lamp house and attaching a more powerful lamp with a special condenser system, a school can use a seven foot screen and obtain ample light on it. The Kodascope is entirely automatic in its operation. Once a film is threaded, there is no need to go near the machine until the film is exhausted, the user can sit at ease among his friends while his pictures are being shown. The machine uses a lens of 2″ focal length and fills the 30″ x 40″ screen at 18 feet distance

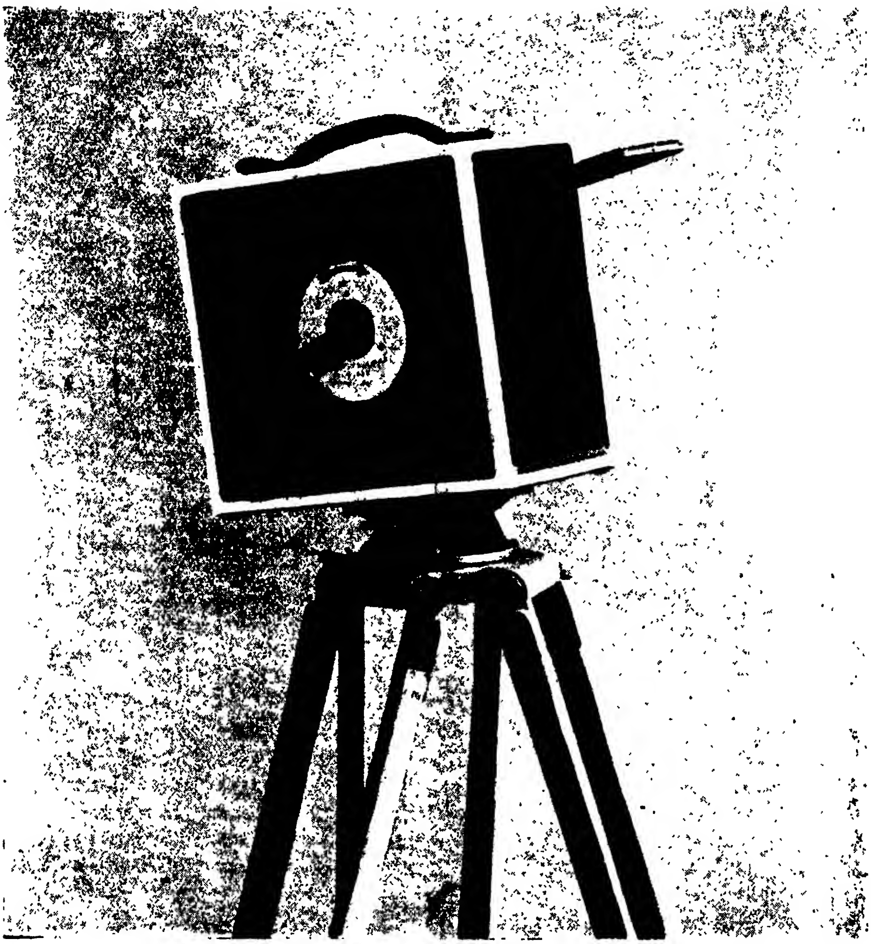

FIG. 6.—Cine Kodak on its Tripod.

and the 40″ x 54″ screen at 24 feet distance. The weight of the Kodascope projector with its motor ready for use is twenty-two pounds.

The quality of the picture depends upon three points: the optical perfection of the systems used in the camera and projector, on which depends the sharpness of the pictures; the mechanical perfection, on which depends the steadiness of the picture on the screen; and the photographic quality of the emulsion and the process used, on which depends the faithfulness with which the brightness in the light intensities in the original pictures are reproduced and its consequent fidelity to nature and also the appearance on the screen as regards any structure or graininess.

Now, when a small film is used for amateur cinematography, the accuracy required on all these accounts is increased, although fortunately the strains both on the film and on the mechanism are decreased. The lenses must be of the highest quality, since the small pictures will be enlarged to a greater degree than big pictures and must consequently be sharper. . The mechanical accuracy must be higher, since any failure in perfection of register will be perceptible. The photographic quality must be at least as good as that of standard size pictures if the user is to be satisfied with the results.

A number of inventors have designed cameras and projectors for amateur use in which the pictures were much smaller than those used on the standard film. The chief difficulty which is introduced when small pictures are used is the graininess which such a small picture shows when it is enlarged upon the screen. A photographic image of any kind is composed of small clumps of the microscopic silver

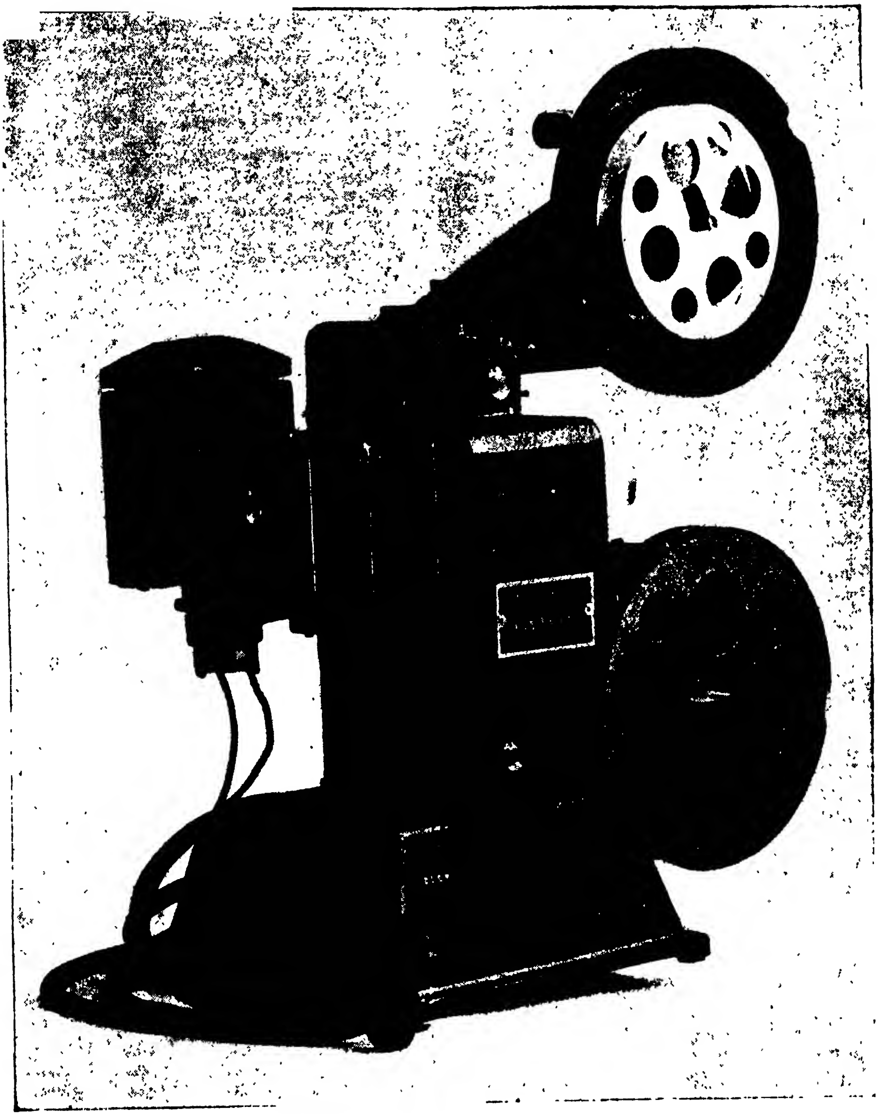

FIG. 7.—Kodascope with lamp house open

grains, and when it is very much enlarged these clumps show and give a structure to the image. In Fig. 8 we see at the left, at A, a very small image, and on the right the same image enlarged 55 diameters. It will be seen that the detail of the image is entirely lost owing to the graininess shown. The graininess in ordinary motion pictures is very slight but is visible when the observer stands close to the screen, and it is clear that if much smaller pictures are to be used on the screen and enlarged to the same extent the results would be greatly inferior to those obtained by the use of standard apparatus and that unless something can be done to diminish the graininess, the results would not be satisfactory in comparison with the pictures shown at the theatres. Moreover, even when a smaller film is used the cost, although diminished, is still high; a negative must be developed and a positive printed from it. This printing requires very skilled work. It is rare in standard motion picture practice for the first print from a negative to be entirely satisfactory, and to get a single print of high quality from every negative would be very difficult. The use of a small film treated like the regular film

FIG. 8.—On left, small image marked A; on right, enlargement of small image to 55 diameters showing graininess.

would, therefore, present two difficulties high cost or low quality of results and the graininess of the image.

The ideal process for amateur use would clearly be one in which the original picture was available for projection on to the screen. In still photography it is an advantage to make negatives, because usually a number of prints are required from a single picture, but in motion picture work in most cases an amateur is interested in getting only a single print, and there are great advantages in a process which enables a positive to be obtained by the first direct treatment of the original exposure. The preparation of positives direct is well known in photography. The usual method is to develop the exposed image and then to dissolve out the silver in a "bleaching" bath, as it is called, which oxidises the silver and leaves the undeveloped silver bromide intact. After exposure to light, this remaining silver bromide is developed in its turn and this gives a positive. This process has two disadvantages: It can give satisfactory results only through a very small range of original exposures because, if the exposure is too low, the amount of silver halide undeveloped is correspondingly large, and the final image is dense, while if the first exposure is heavy, there is not enough silver salt left to form a satisfactory image. It is also dependent upon very exact evenness of coating. If the coating is too thick, then the whole positive will be overlaid by a deposit of silver which the first exposure could not reach, and if it is too thin, there will not be sufficient silver to give density in the final image. Variations in the evenness of coating will show very badly in the finished picture. As the result of a good deal of research work, a process was devised in our research laboratory which overcame these disadvantages. This process depends essentially upon the exact adjustment of the exposure which is given to the residual silver bromide left after the removal of the silver image first developed. It is possible now to obtain first-class positives upon coatings of any thickness whatever, the density not being dependent upon the evenness of the coating, and the control over variations of exposure being quite equal to that obtainable by the usual process of making the positive by printing from a finished negative. Moreover, these reversed pictures were found to be astonishingly free from graininess. The graininess is due to the large clumps of silver halide grains present in the emulsion. These large clumps are more sensitive to light than small or widely separated grains, and therefore when a short exposure is made,

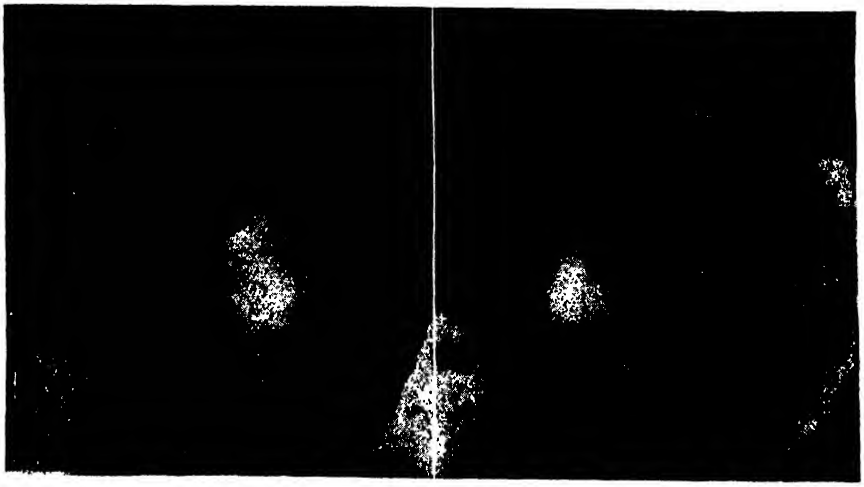

FIG. 9.—Enlargement from standard film and Kodascope positive to same size to show relative graininess, the Kodascope positive being enlarged 2½ times more than the standard film.

the large clumps are the first to become exposed. These are removed in the reversal process, and the final image is made up of the grains of the least sensitiveness. Since these are the smallest grains and the smallest clumps of grains, such a direct positive image shows very little graininess. In Fig. 9 there is shown at the left, an enlargement from a standard motion picture print, and on the right the same scene taken on the small film and enlarged until it is the same size as the picture taken on the standard film. It will be seen that the small film is so free from graininess that a picture of the same size shows no more graininess than if it had been made by the standard process.

The production of the positive by the new

FIG. 10.—Kodascope film side by side with standard film.

process is quite a complicated matter and requires very special and complicated equipment since the film has to go through a great number of treatments compared with the simple operation of developing and fixing to which motion picture film is usually exposed. For this reason it has been decided that for the present, at any rate, the Kodak Company should undertake this work itself, and it is installing equipment which will make it possible to finish all the film that can be taken with the cameras in use.

Naturally, many amateurs will wish to have more than one print for some special reason, and this is provided for by the use of a special printer in which a positive can be duplicated, the duplicate being reversed into a positive in the same way as the original picture. In this way, it is possible to obtain duplicates at the same cost as the original picture, and though this is somewhat higher than the cost of making prints from an ordinary negative, there is no question that the use of the reversal process will greatly cheapen the production of motion pictures by amateurs. The small pictures can be enlarged in special printers to make pictures of the standard size required for theatres. This will, no doubt, not be required very often, but what will be done to a very large extent is that pictures of standard size will be reduced to make the small prints suitable for projection in the Kodascope.

Fig. 10 shows Kodascope film side by side with the standard film. The Kodascope film was standardized at 16mm. in width compared with the standard width of 35mm. The picture is 1 cm. x $\frac{3}{4}$ cm. or 10 x $7\frac{1}{2}$ mm. compared with the standard picture of 1 inch x $\frac{3}{4}$ inch so that the area of the picture is approximately $\frac{1}{6}$ of that of the standard picture. The film has only one perforation on each side per picture while the standard has four perforations. This has the advantage that it is impossible to misframe the picture. If it is framed at all, it must be framed right on the screen. It will be seen that five pictures on this small film occupy the same length as two pictures on the standard film. The small film, therefore, has 40 pictures to a foot whereas the standard film has only 16 pictures per foot, and while a foot of standard film lasts only one second on the screen a foot of the Kodascope film lasts $2\frac{1}{2}$ seconds. The spool used in the Cine Kodak takes 100 feet of the small film, corresponding to 250 feet of the standard film, and the Kodascope projector reel takes 400 feet, corresponding to the standard thousand foot projection reel, which runs for 16 minutes (Fig. 11). The small size of the Kodascope film naturally makes its cost much less than that of standard film. It costs approximately sevenpence to take a negative, develop it, and make one print on standard

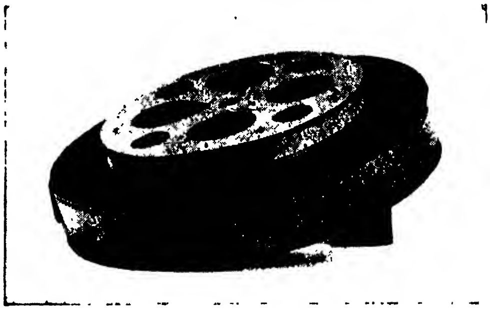

FIG. 11.- Standard reel and Kodascope 400 foot reel.

film for each second on the screen, that is, for each foot of film: so that to make a standard film of 1,000 feet will cost £30. The Kodascope film will cost about a penny-halfpenny a second, so that a reel running for one thousand seconds will cost £6.

In order to get some idea of what this means to the amateur, it is necessary to remember how long a picture should be. Experience has shown that a view of a stationary object or one in which the movement is repeated, such as a waterfall or a game, and in which there is no continuity in the action should last on the screen for between 5 and 10 seconds. This may seem short, but trial shows that if a scene of this type lasts for more than 10 seconds the audience wearies of it. When taking pictures with the Cine Kodak, therefore, it is desirable to give about 7 or 8 seconds' exposure to each scene, moving the camera from one point to another in order to get variety. The cost, therefore, of a single scene taken with a Cine Kodak is about tenpence, and this compares well with the cost of taking an ordinary kodak picture, developing the negative, and making one print. On the whole, it appears as if amateur cinematography with the Cine Kodak will not be more expensive to the user than is still photography.

The film base used for making the Kodascope film is the slow burning film made from cellulose acetate. While the cellulose nitrate

FIG. 12.– Enlargement of single small picture.

film commonly used in motion pictures is entirely safe for theatrical work where proper precautions are taken to prevent any risk of film fires and to quench a fire should it arise, the introduction of such film into the home or school is most dangerous, and one of the great advantages of using a special size of film is that it will not be possible to obtain this film in the fast burning nitrocellulose stock. For the same reason, though to a lesser degree, it is an advantage that this new film cannot be cut from film of standard size by any simple operation. Several small projectors that have been built recently have been made to take half-width film, to be obtained by slitting standard perforated motion picture film in half. While, of course, it is intended that slow burning stock only should be used for this purpose, there is always the danger that someone would be tempted to use the cheaper nitrate stock and to slit it in half for use in the narrow width. The same objection applies with much greater force to the use of projection machines taking film of standard width. It is probable that in the near future there will be a number of projectors on the market and possibly some cameras also taking the 16mm. film, so that the 16mm. size may become standard throughout the entire trade for small film used for amateur film photography just as the professional 1⅜" film used first by Lumiére and Edison became the standard for all motion picture work.

The single small pictures taken on the Cine Kodak can be enlarged, and so fine is the grain and so good the definition that the results of enlargements of these extremely small pictures which, if examined in the hand, need a microscope to see the details are of surprising quality. One of these enlargements is shown in Fig. 12.

The first equipment to be put on the market by the Kodak Company will be in the form of an entire outfit for taking and

projecting the pictures. It will include the camera with its tripod and tripod head, the Kodascope with the screen, and the necessary accessories, such as a device for joining the films together. With the outfit an amateur will be equipped to take his own pictures and project them, or those taken by other people.

The introduction of motion pictures into the home will, of course, produce a demand for pictures other than those taken by the owner of the machine, and we are arranging, therefore, to supply for the Kodascope a library of films made by the reduction of standard reels to Kodascope size. We hope later to have several hundred subjects available, including scenic pictures, stories for children, and pictures of all kinds of a type suitable for use in the home. We believe that the spreading use of the motion picture at home will increase the public interest in the motion picture and will rouse the interest of many people who have not, up to the present, been regular attendants at the motion picture theatres, so that they will follow the progress of the art and will take a real interest in the development of pictures as shown in the large theatres. Just as the widespread use of photography by the amateur has been the chief contributing cause to its marvellous development in the last thirty years and to its extension to every field of human activity, so I believe the use of the motion picture by photographers throughout the world will make possible developments in the art of the motion picture that are at present undreamt of, and that the use of the motion picture in schools, institutions, and homes has a future to which the Cine Kodak and Kodascope will contribute in no small degree.

[During the reading of the paper a cinematograph film was taken of the Chairman, the Secretary, and some other members of the audience; this was immediately developed, and the result projected at the conclusion of the lecture.]

DISCUSSION.

THE HON. STUART A. S. MONTAGU said that he would like to ask four questions of the reader of the paper. In the first place, was it necessary to expose the whole 400 feet of film before it could be developed and inspected? It might be very desirable for the amateur to see what he was doing. Again, was it possible to insert titles and sub-titles as was done in the case of ordinary film productions? He also wanted to know whether any means was provided for slowing down the speed of projection so as to analyse the movements, a thing which might be very useful in connection with training for sports. Finally, could the film be separated and pieces joined together?

MR. T. THORNE BAKER congratulated Dr. Mees on his paper and on the results he had exhibited. There was very little doubt that the instrument he had brought forward would place amateur cinematography on the same basis as ordinary photography had been placed by the snapshot camera. One point of considerable interest to amateurs arose. The amateur after he had exposed his film had to send it to the Company to be developed, and no provision appeared to have been made for the amateur to develop his film himself. Yet surely to a keen amateur the possibility of doing all the work himself in producing the finished result would bring considerable pleasure. Was there any chance of the amateur in the future being given the opportunity of making his own positive? Dr. Mees was further to be congratulated on the excellent way in which he had got over the difficulty of grain in the film. The fact that the least exposed grains were the smallest was one which was apparent from the researches in chemistry during recent years, and it was delightful to observe how the information had been applied in this case to make the small picture as grainless as the large one. Dr. Mees had said that such pictures as he had projected that evening should not be on the screen more than 7½ seconds, but he thought that a good many in that audience could have wished that particular scenes were shown for rather longer, and indeed in certain of the examples Dr. Mees had shown a particular picture for twice that length of time without in the least boring the audience. He feared that in insisting on a 7½ seconds picture Dr. Mees had been infected with American hustle.

DR. MEES, in reply, said that the film used for exposing in the camera was not in 400 feet lengths. It was the film in the projector which was of that length. The film for the camera was in 100 feet and 50 feet lengths. Of course, it was necessary to finish that length before there could be any development. He did not think that such reels were too long. A 50 feet length represented a morning's work for the ordinary man in the ordinary way. In the subsequent handling and finishing of the film the cost for a short length was almost as great as for a long one. There was nothing to prevent the amateur making his titles and sub-titles. His firm could make titles very cheaply, and instead of making his titles for himself, the amateur could avail himself of that if he pleased. With regard to cutting the film, a splicing outfit was provided with the equipment, and was indeed part of the equipment, so that the amateur could join his films together as he pleased. With regard to gearing down for slow motion in order to enable the analysis of motion to be made, this would entail running at eight times normal speed, and a standard camera running at eight times normal speed would

fall to pieces. His firm had not made any preparations for a high-speed camera, though they might do so eventually. But they had discovered how fast they could run this camera, and they found that they could run it at four times normal speed. It could be started and stopped more rapidly than the standard camera, and a gear could be put on in the laboratory to run four times normal speed

With regard to Mr. Thorne Baker's question, the speaker had no vision of the amateur developing his own film. It was a very difficult thing to do. Moreover, 100 feet of film was quite a serpent to play with in the dark-room. The cost of the development equipment would be at least as great as that of the camera, probably more. He could not see any large number of amateurs wanting to struggle with it. He thought that a means of development might be wanted for scientific work; he had had one or two qualms about that. If there was any demand for it, his firm would try to work out a modified reversal process, although this would not afford such control of exposure and would not be so good for the amateur. He was more concerned to provide means in any part of the globe for getting the amateur's work properly finished than to furnish the amateur with means for, perhaps improperly, finishing it himself. In his experience 7½ seconds was quite long enough for the projection of most pictures of this kind; although, of course, the pictures he had shown that evening had been selected as specially good, and in some cases the projection was allowed to be longer. If people really wanted to use more film he would be delighted, but he thought that experience would show when one came actually to take such pictures that 7½ seconds was about the limit.

The Chairman said that that evening would be remembered in time to come as a noteworthy occasion—an occasion on which cinematography had really come into its own. He did not quite agree with the comparative sketch given by Dr. Mees of the development of photography and the development of cinematography. Photography after its invention had at least forty years in which it was chiefly run by amateurs, but in the case of cinematography the art of rendering motion quickly passed into other hands. He believed it was an imaginative Frenchman, M. Pathé, who conceived the idea of acting something that had never actually happened and using the film to illustrate it, and this idea immediately became popular, with the result that there had been enormous commercial and industrial development along these lines. He noticed that very largely in America they measured the value of a film by the cost. A million dollar film was brought out, and this was followed immediately by a two million dollar film, and so on. His own personal view was that the ordinary films on public exhibition were designed for the cure of insomnia. On looking at them he gradually felt himself sinking into a state of coma. But it now seemed possible that there would be some relief from the professional producers of film, and he was glad to hear Dr. Mees say what he did at the end of his paper, because undoubtedly all this complication, all this stage management, all this colossal expenditure, was not necessary for the production of such films as would interest a great many people, especially children. He was quite convinced that the apparatus demonstrated that evening was going to have a very great influence on the future of the cinema. One point which occurred to him was that the ordinary cinematograph production as a result of standardization of film, was current in every part of the globe. Was this sub-standard cinematograph going to have that same advantage? He would be rather interested to know whether there was any likelihood of a sub-standard becoming as international as the full-size standard. He asked the audience to accord a most hearty vote of thanks to Dr. Mees.

The vote of thanks was accorded unanimously.

Dr. Mees, after acknowledging the compliment, said with regard to the standards question that his firm had already persuaded many of the firms in the United States who were experimenting on sub-standard machines to adopt this film. His firm had no objection to their making machines, provided they made good ones. He expected this to become a standard film in exactly the same way as the film for the motion picture houses.

RECONSTRUCTION IN JAPAN.

An interesting article in *Commerce Reports* gives an account of the effect of the recent disaster on Japan's economic statement, and the steps towards reconstruction which are being initiated. The greatest economic loss to Japan, apart from the appalling loss of life, is confined more or less to the material losses in and around Tokyo and Yokohama, which are officially stated to be a little less than $1,000,000,000. This, distributed over the Japanese Empire, will mean a per capita loss of only $13, which, together with the already existing national debt of Japan, will still leave the nation in an enviable position in this respect. As fully 75 per cent. of this insured value will be represented by labour in rebuilding, the increased effort of the Japanese will compensate largely for the loss.

About 75 per cent. of all the buildings in Tokyo were burned or wrecked, while the percentage in Yokohama is estimated to be even greater. The Japanese Government has already signified its intention of creating a ministry of reconstruction for rebuilding the devastated area. This bureau will be greatly assisted in its task by taking advantage of France's experiences in rebuilding the area devastated by the war. It is understood that the construction of anything but temporary buildings has been prohibited in Tokyo, pending the completion of plans and specifications for the rebuilding of the new city.

All problems pertaining to the reconstruction programme will be administered by the ministry. Such material as will be required from abroad to carry out this work will be imported by large Japanese importing houses that maintain branches in the foreign markets, or may be supplied by large foreign firms with branches in Japan. Building material will necessarily be imported in large quantities and considerable economy will be effected by the placing of large orders with individual firms having buying organisations in the United States and elsewhere. Until further notice building materials will enter Japan without the payment of the customary duty.

For several years Japan has been planning to reconstruct and modernise the city of Tokyo. The narrow, crooked streets, and the antiquated buildings were entirely inadequate, and it was recognised that such a transformation was necessary in order that the natural advancement of the city should continue. Some progress in the reconstruction had already been made, and the city boasted of many modern steel and concrete structures, which are said to have withstood the shock and are left intact. Some of the streets had also been widened, especially where it was desired to lay trolley lines. Many other streets had been designated for improvement, but the cost of tearing down and rebuilding was so great, and so many other obstacles were encountered, that the work was lagging while the necessity for improvement was becoming more pressing.

In Yokohama the situation was somewhat similar. The port facilities, while they were being modernised as rapidly as possible, were deficient in many ways, especially as regards warehousing and communication by land to the interior.

The reconstruction ministry will not be faced with any of the old objections and difficulties that handicapped progress before the disaster. The cities have been swept away as if by magic, while the inhabitants remain. The desire for modern cities has been replaced by the necessity of building cities to house the people. Their progressiveness, as well as the rebuilding programmes that have been carried out following similar disasters in other countries, makes it certain that within a few years a new Tokyo and Yokohama will be created that will be modern in every respect, and far better equipped to share in the economic progress of the Japanese Empire.

VITAL STATISTICS OF THE AMERICAN NEGRO.

Some interesting particulars of the Vital Statistics of the American Negro are contained in the Statistical Bulletin of the Metropolitan Life Insurance Company. In past years, vital statisticians have been pessimistic with respect to the American negro's chance for survival under the increased concentration of members of this race in the cities. In fact, for years there seemed to be a marked tendency toward increase in the death rate of urbanized negroes with an accompanying excess of deaths over births. This, some students contended, would lead eventually to the extinction of the city negro. But the plain facts for recent years are entirely opposed to this view, and this can best be seen from the mortality records of negroes insured in the Industrial Department of the Metropolitan Life Insurance Company. These negroes are, for the most part, urban dwellers in Southern as well as Northern communities.

Life-tables show more fittingly than do other measures of mortality just what changes occur from time to time in the expected after-lifespan of population groups. In the two years, 1911-1912, the expected lifespan for coloured male policy-holders at age ten was 41.32 years; in 1922, the expectation was 46.74 years, an increase of about 5½ years or 13.1 per cent. This broadening of the lifespan among negro males may be compared with an increase of 6.3 years or 13.8 per cent. for insured white males over the same period. Among negro females at age ten the expectation increased from 41.30 years in 1911-1912 to 46.07 years in 1922, which is a gain of about 5 years or 11.5 per cent. This is a decidedly better record than the increase of 3.8 years, or 7.5 per cent., for insured white females.

These figures show what has happened to promote the general well-being of the American negro. When the lifespan of a people lengthens by as much as five years over a decade, it is indicative of far-reaching changes in conditions of life and labour. There is no longer any room for pessimism respecting the negro's chance for survival. The members of this race have benefited decidedly and are improving their longevity prospect constantly from wider economic opportunities, and from public health measures.

The northward migration of the race in recent years has probably not had any effect, adversely or otherwise, upon the mortality rates of this insured group. In 1922, 41 per cent. of the Company's business on negro lives was done in the South and South-west, and while this figure is slightly less than that for former years, the change of residence has apparently not had any effect on the life-expectancy figures quoted above. The fact is, that North and South, the condition of the urban negro has steadily improved, and there is no indication that this tendency will slacken. While negro mortality is still much in excess of that among white persons, the gap between the rates for the two races is being closed. Tuberculosis, typhoid fever, malaria and other diseases, which were responsible for excessive death rates among negroes a decade ago, are being brought under control. This is being accomplished by the organized public health movement, and by the negroes themselves through their press and other facilities for dissemination of instruction in hygiene. The most powerful factor of all, however, is the rise in the level of well-being for the negro, brought about by better economic conditions.

THE ISLAND OF GUERNSEY.

Guernsey, which was recently visited by a party of members of the British International Association of Journalists, is one of the most interesting of the Channel Islands. The area (only about 16,000 acres) is very fully utilised, about 10,000 acres being under cultivation. It comes as a surprise to learn that in this small island there are no less than 288 miles of roads, and approximately one motor-car for every 30 inhabitants--probably a larger proportion than prevails elsewhere in the British Isles.

Industrially Guernsey is interesting for the fact that many commodities are both exported and imported. Its genial climate (frost and snow are almost unknown) has made the island famous for the intensive culture of fruit, flowers and vegetables. The interior low-lying portion of the island is practically one vast greenhouse. Land is so valuable that it does not pay to produce most common articles of food in bulk. Growers accordingly concentrate on the production of early fruit and vegetables for export, but, during the cheap season, the same produce is largely imported for home consumption. Thus the earliest potatoes (of which about 2,000 tons were exported in 1922) come from Guernsey, but they are nevertheless largely imported during the summer, and the same applies, in a lesser degree, to strawberries, raspberries and other fruit. Tomatoes are perhaps the most lucrative crop, nearly 18,000 tons being exported in 1922. In the same year about 2,000 tons of grapes were shipped abroad.

Flowers, of course, flourish in Guernsey. Hydrangeas, fuchsias and other shrubs grow in the open to immense size. Upwards of 1,700 tons of cut flowers were exported last year. It is not generally known that Guernsey also supplies considerable quantities of bulbs (chiefly Narcissus, Daffodils and Gladiolus) to growers in Holland for the purpose of enriching their stock.

The granite quarries of Guernsey also form a valuable asset. Although the trade has fallen off somewhat during recent years, 196,570 tons were exported in 1922. Most of the houses in the island are built of this excellent stone, but, as many other materials have to be imported, the cost of building is, on the whole, not particularly cheap. Mention should also be made of the small island of Lihou, which, during the war, was the centre of a valuable process for the production of iodine from seaweed. Another flourishing local industry is the preparation of tobacco and cigarettes. These, like whisky, are approximately half the price current in England. The fact that income tax is only 6d. in the £ (and local taxation and rates are insignificant), forms a strong inducement to retired persons living on their incomes to settle in Guernsey, where life is easy and pleasant. There are still people in the island who have never seen a train. The absence of railways and other inducements to hurry is no doubt partly accountable for the general tendency to "make haste slowly."

The chief scenic feature of Guernsey is, of course, the fine range of cliffs, with many delightful coves and headlands, fringing the southern coast and the south-west corner. Sark, easily reached by motor-boat, offers even grander cliff-scenery, while the nearer and smaller island of Herm has, in its shell-beach half-a-mile long, a singular scientific curiosity. There is a delightfully situated and sporting golf course and the bathing during the greater part of the year is unsurpassed.

Most people visit the Channel Islands during the summer, but the months of April and May, when the wild flowers are at their best, are in some respects the best of all, and the mild climate should also make Guernsey a pleasing autumn and winter resort.

These islands have also an intellectual interest. The geological conditions in Guernsey and Sark and their peculiar local flora and fauna are well illustrated in the Guille-Allès museum, to which an excellent library is attached. The local judicial methods, systems of land-tenure, and folklore are unique, and the isolation of the islands has led to the perpetuation of beliefs and customs of very ancient date. All such matters are the subject of ardent study by the Société Guernsiaise, and visitors who desire to learn more of the beliefs alluded to should make the acquaintance of some of its leading members.

In conclusion, the writer wishes to make grateful acknowledgment of the boundless hospitality of the Guernsey Chamber of Commerce, whose guests the British International Association of Journalists were, and of the courtesy of the Southern Railway Company in furnishing free tickets to and from the island and doing everything possible for the comfort of the party.

J. S. Dow.

THE CHILEAN SULPHUR INDUSTRY.

Chile possesses important sulphur deposits scattered along the entire Andes Mountain chain in close proximity to the numerous volcanoes that are to be found within that region. The development of these sulphur deposits, however, is not always an easy matter. At times the extreme altitude makes the work of extraction practically impossible because of the deep snows covering the ground during the entire winter and even late spring. In other cases the location of the deposits in active volcanic regions such as in Chillan, retards their development. Another handicap to the industry is the absence of roads.

From a report by the United States Vice-Consul at Valparaiso, it appears that the most important sulphur deposits in the country and those that have been developed and worked the most are in the northern zone between the Provinces of Tacna and Antofagasta. In Tacna are the Villa Industrial, Aguas Calientes, Tacora, and Chupiquina mines. These, while well inland, nevertheless have good transportation facilities. The quality of the sulphur is excellent and the mines can be operated during the entire year.

In the Province of Antofagasta are numerous deposits of good quality, the principal ones being the Ancauquilcha, Sierra Ancauquilcha, Cerro San Pablo, Carcote, and Gemelos del Azufre mines. Most of these mines are at present either idle or producing only small quantities of sulphur.

Toward the south deposits of considerable size are to be found. Despite the fact that the grade of sulphur is good, these deposits have been worked but intermittently, due to their location a long distance from the coast, within the line of the heavy winter snows, and to their lack of means of transportation. These mines are situated in the neighbourhood of the baths of El Toro in Coquimbo and in the Province of Atacama. Other deposits that are well known but have never been developed are those of Nuble (near the Chillan volcano) and Colchagua Provinces.

The oldest reliable statistics available date from the year 1887. In that year Chile's production of sulphur amounted to only 0.2 ton. From 1887 to 1902 the total output was 15,000 tons; from 1903 to 1908, 20,833 tons. From 1909 to 1919, inclusive, 115,000 tons were obtained. In the year 1918 production reached its highest point, 19,557 tons. In 1920, 13,340 tons, and in 1921 9,670 tons were extracted.

One of the most important establishments in the country produced during the year 1922 and the first two months of 1923 slightly more than 936 tons of sulphur (all of which was absorbed in Chile), divided as follows: Azufre flor (finely ground or powdered sulphur) for vineyards, 12,754 sacks, shipped to Valparaiso, San Antonio, and Talcahuano; azufre molido (ground sulphur), for the disinfection of stock, 1,219 sacks, shipped to Punta Arenas; azufre molido for industrial uses, 600 sacks, shipped to Valparaiso and San Antonio.

The gradual increase in production up to 1920 was due to the greater demand for sulphur in the manufacture of powder for the nitrate mines, to the progress in the manufacture of chemical products in Chile, and finally to increased exportation abroad. From the following figures the diminishing consumption of sulphur by the nitrate mines can be appreciated: Consumption in 1919—4,000 tons; in 1920—3,800 tons; in 1921—3,000 tons. Production was also influenced by the falling off in the demand for the product abroad; during the three years 1919-1921 exports were: 1919—6,000 tons; 1920—500 tons; 1921—300 tons. Argentina is the principal consumer, with appreciable quantities going to Bolivia, Peru and Uruguay.

GENERAL NOTES.

CARNEGIE INSTITUTE, PITTSBURGH.—The twenty-third International Exhibition of Modern Paintings in Oils will open at Carnegie Institute on April 24th, 1924. The general method of selecting the European paintings initiated last year will be continued. Information and the necessary forms for those desiring to submit paintings can be obtained from Mr. Guillaume Lerolle, European Representative of Carnegie Institute, 14, rue Brémontier, Paris, or from Messrs. Dicksee and Company, 7, Duke Street, St. James's, London, S.W. 1.

NIGERIAN LIGNITES.—A full account is given in the current issue of the *Bulletin* of the Imperial Institute of the lignite deposits of the Southern Provinces of Nigeria, which were discovered during the Mineral Survey carried out under the auspices of the Institute. The deposits exist over a considerable area, some being favourably situated for transport. A detailed study of the lignite in the laboratories of the Institute showed that it was of satisfactory composition and calorific value. It is quite suitable for briquetting, and briquettes used as fuel in firing trials in railway engines and steamboats in Nigeria have proved satisfactory.

FLAX GROWING IN SOUTH AFRICA.—As a result in the decline of flax production in Russia and Ireland, growers have been compelled to seek new sources of supply, and among these the one that promises to be most suitable for flax production upon a large scale is South Africa. An English expert selected the Western part of Cape Province as presenting the most favourable soil, and Russian seed was widely distributed to farmers for experimental purposes. It is stated that these experiments proved very successful. The growth has been very satisfactory and, according to the United States Trade Commissioner at Johannesburg, it is possible that these experiments will finally result in the opening up of a new field for South African agriculture.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock:—

DECEMBER 5.—ARTHUR WILLIAM HILL, M.A., Sc.D., F.R.S., F.L.S., Director of the Royal Botanic Gardens, Kew, "The Work of the Royal Botanic Gardens, Kew." CHARLES ALBERT SEWARD, M.A., F.R.S., F.G.S., F.L.S., Professor of Botany in the University of Cambridge, will preside.

DECEMBER 12.—SIR FRANK BAINES, C.B.E., M.V.O., Director of Works, H.M. Office of Works, "The Preservation of Historic Buildings and Ancient Monuments." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

DECEMBER 7.—WILLIAM FOSTER, C.I.E., Historiographer, India Office, "The Archives of the Honourable East India Company." (Sir George Birdwood Memorial Lecture.) THE RT. HON. VISCOUNT PEEL, G.B.E., Secretary of State for India, will preside.

DOMINIONS AND COLONIES SECTION.

Monday afternoon, at 4.30 o'clock.

DECEMBER 17.—WM. C. NOXON, Agent-General for Ontario, "Empire Settlement." The EARL OF AIRLIE, M.C., will preside.

PAPERS TO BE READ AFTER CHRISTMAS.

G. ALBERT SMITH, "Cinematography in Natural Colours—further developments" (with illustrations—scenes from H.R.H. The Prince of Wales's Tour in India).

IYEMASA TOKUGAWA, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

SIR RICHARD ARTHUR SURTEES PAGET, Bt., "Fused Silica and its use as a Refractory Material."

H. MAXWELL-LEFROY, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle."

PERCIVAL JAMES BURGESS, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber."

CHARLES S. MYERS, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation."

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

SIR RICHARD M. DANE, K.C.I.E., Commissioner North India, Salt Revenue, 1898-1907; Foreign Chief Inspector, Salt Revenue, China, 1913-18, "Salt Manufacture in India and China."

BRIGADIER-GENERAL HENRY ALFRED YOUNG, C.I.E., C.B.E., late R.A., Director of Ordnance Factories, India, 1917-21, "The Indian Ordnance Factories and Indian Industries."

JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

COLONEL H. L. CROSTHWAIT, C.I.E., R.E., retd., late Superintendent, Survey of India, "The Survey of India." Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., Rector, Imperial College of Science and Technology, will preside.

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

F. W. WALKER, "The Commercial Future of the Backward Races, with Special Reference to Papua." SIR GEORGE R. LE HUNTE, G.C.M.G., will preside.

THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

January 4, 18, February 15, March 21, May 2.

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock.

February 5, March 4, April 1, May 27.

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

ALDRED F. BARKER, M.Sc., Professor of Textile Industries, The University, Leeds, "Recent Progress in the Wool Industries." Two Lectures. December 3, 10.

SYLLABUS.

LECTURE I.—December 3rd. Raw Materials:—Brief review of developments of the past hundred years. Basic principles revealed by this review. Present-day experimental researches, including the Mendelian Researches of the Universities of Cambridge, Edinburgh and Leeds. Colonial Experimental Research with special reference to Australian and Cape wools. Peruvian Experiments. Colonel Stordy's experimental researches with reference to Alpaca and Vicuna. Mr. Stefansson's suggestion respecting Ovibos Fibre in the Arctic Circle. Introduction of new fibres into the Wool Industry.

LECTURE II.—December 10th. Processes:—Brief review of developments of the past hundred years. Basic principles revealed by this review. Recent improvements in the principles of manipulation of the raw materials. Recent mechanical developments. Prospective manipulative and mechanical developments. Distribution of the Industry:—The present distribution and the principles of distribution involved. Prospective distribution.

ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University Cambridge, "Colloid Chemistry." Three Lectures. January 21, 28; February 4.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

COBB LECTURES.

Monday evenings, at 8 o'clock.

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures March 24, 31; April 7.

DR. MANN JUVENILE LECTURES.

(*Special tickets are required for these Lectures*).

Wednesday afternoons, at 3 o'clock.

DR. WILLIAM ARTHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology. "Fire and Explosions." Two Lectures. January 2, 9. The Lectures will be fully illustrated with experiments.

MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, "Among the Selkirk Mountains of Canada (with ice-axe and camera)." One Lecture. January 16. The Lecture will be fully illustrated with hand-painted lantern slides.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, DECEMBER 3.. Geographical Society, 125, New Bond Street, W., 8.30 p.m. Sir Charles Bell, "A Year in Lhasa."

Swiney Lecture, King's College, Strand, W.C., 5.30 p.m. Dr. W. T. Gordon, "Gem Minerals and their Uses in Art and Industry." (Lecture VII.)

Alpine Club, 23, Savile Row, W., 8.30 p.m. Dr. C. Wilson, "Climbing in the Bregaglia."

Chemical Industry, Society of, at the Chemical Society, Burlington House, Piccadilly W., 8 p.m. 1. Mr. J. Allen Howe, "The Use and Preservation of Building Stone." 2. Messrs. J. J. Fox and T. W. Harrison, "The Chemical Aspects of Building Stone Decay."

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Mr. J. W. Gordon, "Railway Surveying by Photography."

Textile Institute (London Section), 38, Bloomsbury Square, W.C., 5.45 p.m. Prof. W. Davis, "Knitted Fabrics."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 7 p.m. Informal Meeting. Discussion on "Electrical Apparatus for the Deaf."

Automobile Engineers, Institution of, The College, Loughborough, 7 p.m. Mr. L. Murphy, "The Misuse of the Internal Combustion Engine and Suggestions for its more Efficient Application."

Transport, Institution of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C., 5.30 p.m. Mr. C. Travers, "Railways of To-day and To-morrow."

TUESDAY, DECEMBER 4.. Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Mr. H. Balfour, "Observations on the Technology of the Nagas of Eastern Assam."

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Marine Engineers, Institute of, 85, The Minories, Tower Hill, 6.30 p.m. Mr. J. H. Anderson, "Spontaneous Ignition of Coal."

University of London, King's College, Strand, W.C. 5.30 p.m. Miss Hilda Oakeley, "The Roots of Early Greek Philosophy." (Lecture II.)

WEDNESDAY, DECEMBER 5.. University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. W. C. Berwick Sayers, "Library Classification in Modern Life."

United Service Institution, Whitehall, S.W., 3 p.m. Vice-Admiral V. H. G. Bernard "The Supply and Training of Officers for the Royal Navy."

Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W. 8 p.m. 1. Mr. H. Toms, "Crystalline Bromides of Linseed Oil." 2. Mr. M. S. Salamon, "The Plea for Standardisation." 3. Mr. H. T. S. Britton, "Note on the Estimation of Chromium." 4. Mr. R. L. Andrew, "The Colorimetric Estimation of Lead in Cream of Tartar."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. J. Sexton, "Can Industry be divorced from Politics."

Swiney Lecture, King's College, Strand, W.C., 5.30 p.m. Dr. W. T. Gordon, "Gem Minerals and their uses in Art and Industry." (Lecture VIII.)

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. (Wireless Section.) Mr. L. B. Turner, "The Relation between Damping and Speed in Wireless Reception."

Archæological Institute, at the Society of Antiquaries, Burlington House, Piccadilly, W., 5 p.m. Mr. A. Oliver, "Some French Abbeys and Cathedrals."

THURSDAY, DECEMBER 6.. Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1. Mr. C. K. Ingold, "The Additive Formation of four membered rings. Part III. A System of Nomenclature for Heterocyclic four membered Rings and the formation and Properties of some Derivatives of β-methylenedi-imineoxide." 2. Messrs. H. J. S. Sand and E. J. Weeks, "The Dependence of Polarisation-overvoltage on Hydroxyl and Hydrogen Ion Concentration. Part I. Polarisation-overvoltage of an Antimony Cathode in Aqueous Alkaline Solution." 3. Mr. H. King, "Stereoisomerism and Local Anaesthetic Action in the β-Eucaine Group. Resolution of β- and iso-β-Eucaine." 4. Mr. A. Green, "β-alizarin. An isomeric form of Alizarin." 5. Messrs. O. L. Brady and F. P. Dunn, "The Isomerism of the Oximes. Part XV. The supposed fourth Benzildioxime." 6 Messrs. W. E. Garner and F. C. Randall, "The alternation in the Heats of Crystallisation of the Normal Monobasic Fatty Acids."

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Mr. L. Brooks, "The Beginnings of Geographical Teaching."

London County Council, at the Geffrye Museum, Kingsland Road, E., 7.30 p.m. Major A. A. Longden, "The Modern Home."

Auctioneers and Estate Agents' Institute, 34, Russell Square, W.C., 6.30 p.m. Mr. H. Ambler, "Tithes and Tithe Rent Charges."

FRIDAY, DECEMBER 7.. University of London, University College, Gower Street, W.C., 5.15 p.m. Prof. Karl Pearson, "Eugenics."

Swiney Lectures, King's College, Strand, W.C., 5.30 p.m. Dr. W. T. Gordon, "Gem Minerals and their Uses in Art and Industry." (Lecture IX.)

Philological Society, University College, Gower Street, W.C., 8 p.m. Mr. C. R. Enock, "Euphratean Origin of Man, Language and Place-Names."

Mechanical Engineers, Institution of, Glasgow, 7.30 p.m. Sir Westcott Abell, "The Mechanical Problems of the Safety of Life at Sea" (Thomas Hawksley Lecture).

(Yorkshire Branch). Leeds, 7.30 p.m. Mr. F. Clements, "The Forces of Nature in the Service of Man."

Geologists' Association, University College, Gower Street, W.C., 7.30 p.m.

Timber Trade Lectures, Council Chamber, London Chamber of Commerce, Oxford Court, Cannon Street, E.C., 6.30 p.m. Mr. P. F. Turner, "Chartering for Timber Cargoes."

Journal of the Royal Society of Arts.

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FRIDAY, DECEMBER 7, 1923.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2).

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 10th, at 8 p.m. (Cantor Lecture.) ALDRED F. BARKER, M.Sc., Professor of Textile Industries, The University, Leeds, "Recent Progress in the Wool Industries." (Lecture II.)

WEDNESDAY, DECEMBER 12th, at 8 p.m. (Ordinary Meeting.) SIR FRANK BAINES, C.B.E., M.V.O., Director of Works, H.M. Office of Works, "The Preservation of Historic Buildings and Ancient Monuments." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., will preside.

Further particulars of the Society's Meetings will be found at the end of this number.

DOMINIONS AND COLONIES SECTION.

TUESDAY, NOVEMBER 27th, 1923; LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair.

A paper on "The West Indies" was read by VISCOUNT BURNHAM, C.H., LL.D., D.Litt.

The paper and discussion will be published in the *Journal* of December 14th.

FOURTH ORDINARY MEETING.

WEDNESDAY, NOVEMBER 28th, 1923: LORD DAWSON OF PENN, G.C.V.O., K.C.M.G., M.D., F.R.C.P., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Avram, Möis H., New York City, U.S.A.
Davis, Neville Ryland, London.
Duitz, Emile A., Amsterdam, Holland.
Gray, Roland, Boston, U.S.A.
Lang, Reginald, Plymouth.
Morrow, George Leslie, Berkhamsted, Herts.
Rayner-Smith, Percy, London.
Williams, Lennard, Tilehurst, Berks.
Williams, Stephen Miller, Arkansas, U.S.A.

The following candidates were duly elected Fellows of the Society:—

Burnham, Walter Witt, London.
Jack, James, New Cumnoch, Ayrshire.
Jacques, Gilbert J.P., Ontario, Canada.
Markgraf, Miss Agnes, The Hague, Netherlands.
Peterson, President Elmer George, Ph.D., A.M., B.S., Logan, Utah, U.S.A.

A paper on "The Effect of Sun, Sea and Open-air in the Treatment of Disease," was read by SIR HENRY JOHN GAUVAIN, M.A., M.D., M.Ch., Medical Superintendent of the Lord Mayor Treloar Cripples' Hospital.

The paper and discussion will be published in a subsequent number of the *Journal.*

REPRINTS OF CANTOR AND HOWARD LECTURES.

The Cantor Lectures on "The Vulcanisation of Rubber" by HENRY P. STEVENS, M.A., Ph.D., F.I.C., and the Howard Lectures on "The Development of the Steam Turbine" by STANLEY S. COOK, B.A., M.I.N.A., M.I.M., have been reprinted from the *Journal* and the pamphlets (price 2s. each) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures, which have been reprinted and are still on sale, can also be obtained on application.

MANN JUVENILE LECTURES.

Under the Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 2nd and 9th January, 1924, at 3 p.m., by DR. WILLIAM ARTHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology, on "Fire and Explosions." The lectures will be fully illustrated with experiments.

A lecture will also be given on Wednesday, January 16th, at 3 p.m., by MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, entitled "Among the Selkirk Mountains of Canada (with ice-axe and camera)." The lecture will be fully illustrated with hand-painted lantern slides.

Special tickets are required for these two sets of lectures. A sufficient number

to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once stating for which lectures the tickets are required.

PROCEEDINGS OF THE SOCIETY.

THIRD ORDINARY MEETING.

WEDNESDAY, NOVEMBER 21st, 1923.

THE SECRETARY announced that Lord Crawford had sent an expression of his great regret that he had suddenly been called to Manchester on urgent business and would therefore be unable to take the Chair as arranged. Mr. Bernard Rackham, of the Victoria and Albert Museum, had very kindly consented to take Lord Crawford's place at very short notice.

THE CHAIRMAN said he would like to add his word of regret that Lord Crawford was not able to be present that evening. It might not be known to everyone that Lord Crawford had lately added to his numerous public-spirited activities by becoming the second President of the Society of Master Glass Painters, in succession to the late Lord Plymouth.

Before reading his address, Mr. Knowles paid a tribute to the memory of the late Maurice Drake, who, he said, had been so greatly interested in the subject of ancient stained glass, and who had made the subject his own.

The following paper was read:

FORGERIES OF ANCIENT STAINED GLASS:

METHODS OF THEIR PRODUCTION AND DETECTION.

By J. A. KNOWLES.

There is no greater enemy of all true lovers of old work and old craftsmanship than the forger. Even to those who feel nothing of the joy of possession, which is the essence of collecting, but who look to make a living, and an honest one, by buying and selling, the forger does the very greatest harm. They are very frequently his victims, whilst his productions have turned up so frequently in auction rooms that both private individuals and dealers are very shy of bidding for something which may eventually prove to be worthless, and, therefore, sometimes absolutely genuine specimens are passed over or sold for a small figure. Unfortunately, glass is a subject which is very little understood, and whilst there must be scores of people who are capable of giving expert advice on an oil painting and hundreds of others who have sufficient knowledge to exercise a very sound judgment in such cases, those who are similarly equipped with a knowledge of glass painting are comparatively few. Yet in spite of the fact that forgers, no doubt, will always exist as long as there are those who can be taken in, though I cannot in any way claim the title of "expert," I will as a practical glass-painter endeavour to show by what means forgeries are produced and some methods of detecting them.

Before going into the subject in detail it may be well to discuss the subject in its general aspects. In the first place there is an essential difference between a forgery and a reproduction. The essence of this difference lies in intention. Reproductions and copies of old work have, for example, been made for museums overseas, where it is next to impossible to obtain original glass. Such are clearly labelled and the names of the artists who were responsible for them stated as a tribute to an excellent and painstaking piece of work. They have also been done in such cases as where glass has been shivered to fragments by having cold water played upon it whilst it was heated when churches have caught fire, and where to remove the glass from the lead would spell disaster. Such a case occurred in connexion with one of our large northern churches, and the copy has preserved to us a facsimile of the original glass so exactly like the original that it would be difficult to say which was which. All such copies should be, and generally are, signed, marked and dated; whilst at the same time no attempt is made to imitate the corrosion of the glass so that they are in no way intended to take the public in. On the other hand, a forgery is an iniquitous piece of work in that it is an attempt to extort sums, and frequently very large ones, under false pretences.

Glass is a comparatively fragile* material,

* The statement that glass is only *comparatively* fragile has not been made without due thought or consideration. One cannot but marvel for example that pieces of glass are frequently to be seen, such as those in St. Michael's, Spurriergate, York, of the most complicated and difficult shapes to cut and glaze, which have remained intact for hundreds of years without a break or crack in them. Other examples are the quarterings of the shields frequently to be seen in England and France where the charges, three fleur de lys, have been let into a piece of blue glass in which three lozenge-shaped holes have been drilled and cut to receive them, yet the glass has remained intact to this day.

so that old circles where a scene, shield of arms, or what not has been painted on a single piece of glass of six or eight inches in diameter, are generally cracked across in one or two places, and these cracks have been repaired with leads in order that they may appear old. Spurious examples generally have a few cracks across them, too, but as a rule the forger cannot bring himself to cut or break them across the most interesting part, such as the head, where, as we are painfully aware, such breaks, seemingly through the sheer perversity of things, generally do occur, but he cuts or breaks the pane in such a way as to damage the subject as little as possible.

Doubtful examples should, if possible, be taken out of the lead and the breaks examined. If the edges of the various pieces do not fit together as exactly as the two halves of a biscuit which has been broken in two, the specimen is spurious. The edges should also be examined to see whether a diamond has been used to cut the circle up into pieces in imitation of breaks. This can be seen with a good lens, as a diamond slightly scratches and chips the surface, whereas a break is perfectly clean. If the breaks or cracks are many and it has been necessary at some earlier period to re-lead the panel, the pieces may, of course, have been grozed down by chipping off fragments from the edges with the pincers in order slightly to reduce each piece in size so as to make room for the core of the lead. Thus, for example, in a panel, originally of a single piece of glass one foot in diameter, if there are eight cracks across it, and the core of the lead measures 1/16th of an inch ; half an inch would have to be taken off the glass somewhere in order to keep the pane its original width. The various pieces of such a pane, therefore, would not fit exactly together when taken out of the lead, as each one had been more or less whittled down. But old glass is never perfectly flat, but always more or less reamy, wavy, undulated and bubbly. It is, therefore, necessary to notice carefully whether the waves, bubbles and undulations are continuous from one piece to another, such as one would expect in a single piece of glass which had been broken, and that the panel has not been formed of six or more different and distinct pieces of glass in which the waves and bubbles do not pass naturally from one to the other, but go off in different directions.

Forgers even buy up panes of glass from old windows and paint on them so that, though the glass may be comparatively old, the painting is new. But the difficulties of obtaining glass of this kind except in the form of diamond panes or "quarries," are great, and of any size next to impossible ; for formerly windows were leaded in panes which did not average more than six by four inches in size, and much of the glass used for this purpose was not the fine glass of Lorraine, such as the old glass-painter set such store by for painting on, but the Dutch and German glass, or in England, Newcastle glass, which was of an ashen tint and very reamy.

The outside edges of the pane of glass should also be examined to see if it has been cut to shape with a diamond. It might, of course, as previously mentioned, have been trimmed down at some comparatively recent period, but if there is no reason to believe that this has been done, a straight clean cut, such as is obtained by the use of a diamond or a wheel, gives away the panel at once, and any glass which shows this, and which is supposed to belong to a period anterior to 150 years ago, is extremely likely to be modern. I am quite aware that a diamond is mentioned for cutting glass in the fifteenth century Bolognese M.S.,* also that Vasari tells us William of Marseilles employed an emerald for the same purpose. But that these were not used in Jost Amman's time, 1539-1591, is shown by his drawing of a glazier at work. Moreover, these early diamonds cannot have been of much practical value and were probably the cause of the breakage of more glass than they cut. The essence of the process is in the setting of the stone, the cutting edge of which must be in a straight line with the line being cut, otherwise a scratch and not a cut results. The early diamonds mounted in pencil form, which could be twisted and turned in any direction, would do very well for writing on glass ; but would be of little use for cutting it. Le Vieil* tells us that it was not until about 40 years before his time (*i.e.*, about the year 1730) that diamonds were first mounted in a flat ended handle, whilst Shaw's diamond, where the cutting edge is trued up parallel to the edge of a steel block, which when held against the lath causes the diamond to make a clean and

* Printed in Mrs. Merrifield's *Original Treatises on the Arts of Painting.* Vol. II.

* *Art de la Peinture sur Verre.* 1774.

continuous cut, was only patented as recently as 1815.

Before a really practical diamond was introduced and regularly employed, glass was first roughly shaped with a hot iron and then nibbled to the exact form desired with a grozing-iron. This was a little iron instrument like a small lath or ruler with a notch in the edge, similar to the notch still to be seen in the end of the modern cutting wheel, which is used—though perhaps very rarely, as a pair of pliers does the job much better—for breaking off small strips which are too narrow to be gripped by the fingers. The grozing iron was worked on the edge of the glass so as to break off little chips. The edge of old glass, therefore, is always slightly toothed or jagged. To imitate this, which is such an elementary fact that it is known to all imitators, the pliers are employed. But the result is not quite the same. If we examine the edge of a piece of glass which has been cut in the old way, we see it has a sharp chisel edge, the edge being to the upper or painted side of the glass. But

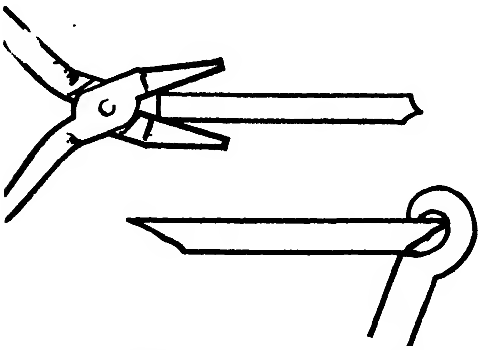


FIG. 1.—METHODS OF SHAPING GLASS.

Modern, with Pliers—Chips break away from both upper and lower faces of the piece.

Ancient, with Grozing Iron.—The edge of the glass is chisel shaped.

the pliers are very liable to take chips off both the upper and the lower surfaces of the glass, for both surfaces are gripped equally between the jaws.

We will now leave the question of these panes of glass painted originally on one single piece, and turn to panels of larger size, such as are made up of a great number of pieces of glass of many different colours, as in the case of church windows.

As an aid to determining whether or not a glass painting is a forgery, a thorough knowledge of the technical history of the art is very important, for it is in this and not in dexterity of hand that the forger most frequently gives himself away, through not knowing at what periods the various improvements in the material and methods of working were introduced. A glass painting which, for example, shows the use of yellow stain before the beginning of the fourteenth century, is in the highest degree likely to be a forgery, for the earliest known example is dated about the year 1310.* Specimens presumably earlier than the fifteenth century which show jewels fluxed on or holes drilled and pieces inserted are as likely as not spurious. Glass which purports to have been executed during the fifteenth century, but which shows the use of enamels, is almost certainly a forgery. The use of acid cannot appear before the seventeenth century, and even then would be open to grave doubt; also the use of a pink glass which owed its colour to gold. Panels of church windows which pretend to belong to the second half of the seventeenth century, yet which show a profuse use of coloured glasses, are, doubtless, fakes, for in 1636 Louis XIII. destroyed all the glass factories of Lorraine, and thereby made coloured glass for church windows practically unobtainable. About the same time the secret of making ruby glass was lost, and though it appears again once or twice later, it was not in general use till after its re-discovery in 1826. No panel which contains green glass which, on analysis, proves to have been made from chromium oxide can be earlier than the eighteenth century as that metal was only then discovered by Scheele the chemist. Kilns with separate trays with but one layer of glass on each, which system enables the enamel to be fired up to a bright and glossy surface, were not introduced till 1758, and nearly fifty years later Peckitt, of York (1731-1795), was still using the old way of a pan filled to the top with alternate layers of glass and whitening. Machine-made rolled cathedrals, blown Norman slabs, and coloured sheet glasses are no older than the nineteenth century, as also are anbittie and sanded sheets.

I can well imagine some eminent counsel after much midnight oil and study of the Encyclopædia Britannica, making great play with the above conclusions, and showing to the confusion of a witness that they are quite wrong by pointing out that "fluxed

* The Peter de Dene window in the Nave of York Minster.

on" jewels are mentioned by Theophilus, a writer of the twelfth century, that enamels were used on hollow ware for centuries before the year 1500, and that Claud of Marseilles, before the beginning of the 16th century, painted a window in enamels for the study of the French Ambassador at Rome. That acid is described in the fifteenth century Bolognese M.S., and a red derived from gold was probably known to the Saracens, and is also described in the MS. previously mentioned more than two hundred years before its reputed inventor, Andrew Cassuis the younger, lived. All this is perfectly true, but it does not prove that any of these things came into general use, or, indeed, that any specimen of them is known in any public or private collection before the times mentioned above.

The Glass.

The painting of a forged panel may have been so skilfully executed as to deceive an expert. But unless the glass upon which it has been done exactly corresponds in every particular with glass of the corresponding period of that to which the forgery pretends to belong, it must be rejected. The various characteristics which it must possess are many, and the difficulties of finding glass at the present day which will agree with all of them are great. The material on which the painting has been done must agree in

(i) Thickness.
(ii.) Texture.
(iii.) Wavyness.
(iv.) Tint.
(v.) Ability to stain without "metalling."

(i.) Thickness. As a general rule all ancient glass is thinner than modern. It is perfectly true that the mediæval workers were fully alive to the value of substance in glass and they also knew perfectly well that thick glass tones and filters the light as it passes through it better than thin glass does, even if the two are exactly equal in tint. But they were not always able to obtain it. Inigo Jones complained that Sir Robert Mansell, who tried to corner the glass industry in England during the seventeenth century, made very thin glass, and long before this, in 1485, at Toledo, we read that the cathedral authorities handed Master Henry the glass-painter a sum of 150,000 "maravedis" and told him "to proceed to Flanders or any other part he may desire where good glass is to be had (of white, blue, green, ruby, purple, yellow, and blackish (*prieto*) colours) and *equal in thickness to the sample which he bears*, and bring us thence such quantity as he has need of for the windows of our cathedral."* But to produce a sheet of glass of both large size and of considerable substance requires a large gathering of metal, and a strength of arm and skill in manipulation which the old glass makers were not equal to. Their glass, therefore, was made in both smaller and thinner sheets than ours is. Most of the glass after the fifteenth century was very thin indeed. In speaking of modern glass I am, of course, referring to modern "antique" glass, which is made purposely for stained glass work. That made in England at the present day is undoubtedly the finest in the world. Its thickness gives it a tone and quality which is unequalled by any other, so that glass painters from all over the world send for it for their best work. But this very quality renders it useless to the forger, who has, therefore, to use foreign antique or what are known as sanded, specky, anbitiie, and tinted sheet glasses.

(ii.) This brings us to the question of texture. It is very difficult to lay down any hard and fast rule on these matters, but generally speaking, modern antique, and especially that made in England, has more bubbles in it than the old. These are purposely left in the glass as they make it more brilliant. But in glasses which are intended to be used for painting heads upon, bubbles are out of place and another means of obtaining brilliance is resorted to. The marver upon which the bulb of metal (*i.e.*, glass) is rolled before it is blown has lines upon it and these lines appear on the back of the sheet of glass and make it shimmer. This is never seen in old glass. Sanded sheet is formed by sprinkling sand on the floor of the kiln in which the cylinders of glass are flattened out into sheets. The particles of sand cause depressions in the surface and seme of them adhere to the glass itself. This, too, is an impossible feature in old work.

(iii.) Though old glass may appear perfectly flat in small pieces, it is nearly always wavy and cockled on the back. This is particularly to be noted in circles and so forth of five or six or more inches

* *Documentos Ineditos para la Historia de las Bellas Arte en Espana*, by Zarco del Valle.

in diameter upon which emblems and similar designs were painted. This was caused by the inability of the old glass makers to rub their glass down to a perfectly level surface in the flattening kiln, as is done nowadays in the manufacture of large sheets of glass, such as are used for framing pictures and for windows in houses. This only applies to such ancient glass as was produced by the "muff" process, which was formed from a large cylinder of glass which was slit down the side and opened out into a flat sheet. Old, as well as modern, "crown" glass, which consists of a circular sheet produced by whirling, does not suffer from this defect, as it has not to be flattened like the muff. To simulate the cockling and waviness of ancient muff glass, imitators are in the habit of heating it in the kiln on a tray on which the whiting has not been evenly spread, but has been left in lumps and ridges. The glass is heated to softness when it sinks down into slight hills and valleys similar to the old.

(iv.) Tint. Although the use of manganese as a decolorizer was understood and constantly employed, a perfectly colourless glass is never seen in old work. In the mediæval period, whilst greenish tinted glasses are frequent, after the fifteenth century they should be regarded with suspicion, as the old glass-painters greatly favoured the glass of Lorraine for their work on account of its valuable staining qualities, and this glass was slightly yellowish in tint.

(v.) Ability to stain. Whereas modern glass is almost invariably a sodium calcium silicate, analysis has proved that the old was almost always a potassium calcium silicate. In untechnical language, where the old workers used potash as the source of their alkali, we use soda. This fact has a very important bearing on the subject of forgeries, for there is an enormous difference between the way in which a soda-lime glass takes the yellow silver stain, and one in which the alkali employed in its manufacture is potash. For, as Mr. Noël Heaton pointed out in paper read some years ago before this Society,* the stain on a soda-lime glass is not equal to that which is communicated to a potash one. The modern glass also, in staining, very frequently "metals," *i.e.*, if you look on the back of a piece of modern glass where the yellow stain has been applied, it shows as a nasty opaque mustard yellow. Now, I do not mean to say that this effect is *never* seen on old glass, as I have a fragment in my possession which is undoubtedly ancient and yet shows this defect, but it is very unusual indeed, and in this case is only due to the fact that the glass has been so greatly over-fired as to be almost melted.

THE ENAMEL.

So much for the glass itself. We next come to the question of the enamel with which the glass has been painted, and by "enamel" I do not mean coloured enamels. These we will discuss later—but merely the opaque brown, red or black pigment which is used for painting the outlines and giving the various shades and tones of the painting. I will not go into the question of the composition and characteristics of the opaque enamels and their variations at different periods in minute detail to-night, as I fully discussed the subject in a paper read before this Society some years ago, to which I would refer those who wish to pursue the subject further.* As I there pointed out, the colour of the enamel of different periods seen by reflected light can roughly be classified as follows:

12th and early 13th centuries	Black.
13th, 14th & 15th centuries	Purple or red.
16th to 18th century	Black.

When an ancient glass-painting is held up to the light and the enamel is judged by transmitted light, it varies in what little amount of colour it imparts to the glass from a rich warm brown to a cool black. It, however, never suffers from a defect which is very common, though by no means universal, with modern glass-painting enamels, and that is "foxiness." What glass-painters term "foxiness" is a peculiar reddish cast communicated to the painting, to be seen when it is viewed at an angle instead of from a point directly in front, which is caused by a partial reflection of light from the particles of metallic oxide of which the enamel is made, some of the light passing through the panel and some being reflected back from it. Here, for example, on the screen are two forgeries of 16th century medallions, which show this. Again, in a genuine example of ancient work the traced lines must be perfectly opaque

* **Mediæval Stained Glass: Its Production and Decay.** *Journal of the Royal Society of Arts*, March 15th, 1907.

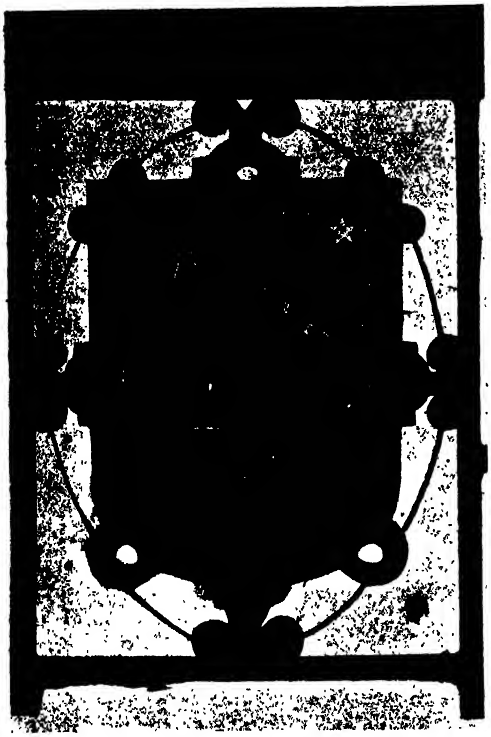
* **Technique of Glass-Painting in Mediæval and Renaissance Times.** *Journal of the Royal Society of Arts*, May 15th, 1914.

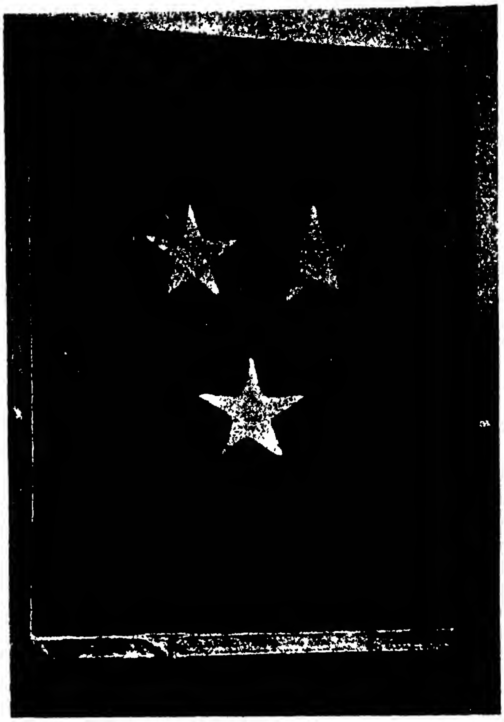
where it was so required that they should be without the line having had to be loaded with enamel in order to achieve this result, and thereby stand up above the rest of the surface of the painting. Generally speaking, the modern enamel is greatly inferior in density to the old, and the lines frequently are semi-translucent instead of being perfectly dense and absolutely opaque and, therefore, black.

The old enamel, either from atmospheric influence or from insufficient firing, frequently chips off. Winston, the great authority on glass, states that he never came across an old example which could not be scratched off with a knife, and though it would be best to accept this statement with reservations, it is certain that the old enamels are never fired down as tight as the modern. Renaissance glass-paintings are particularly liable to be scratched, owing to insufficient flux in the enamel and not enough heat. The chipping of the mediæval colour in inscriptions and so forth is imitated by moistening the colour, which is held to the glass with gum alone, with an old creased and ragged wet chamois leather pressed against the glass. When this has been lifted off it brings some of the outlines and painting with it, and gives a fair imitation of the real thing.

COLOURED ENAMELS.

We have already discussed the brown or black opaque enamel used on the front of the glass to give the outlines and shading; we will now consider the coloured transparent enamels—blue, red, purple, etc.—which are generally applied to the back of the glass. As a general rule it may be laid down that except in some few exceptional cases that one occasionally comes across, the old enamels were never equal in brilliancy and transparency to those of the present day, and especially to those modern enamels of Continental origin. All this favours the detection of frauds, for most of the forgeries of the present day being made on the Continent, the producers of them employ enamels of French or German make, which, no matter how superior they may be to the ancient ones, do not match them nearly so well as English enamels do. The ancient enamels were very hard. They were, moreover, not laid on a tray in the kiln, but were fired in a pan filled to the top with whiting and glass in alternate layers one above another. They did not, therefore, fire up bright, as the contact of the enamel with the lime or whiting prevented this. At most they have but an eggshell gloss on the surface, and this was in most cases confined to the blue. Modern Continental enamels, on the other hand, are very soft. So much so that if any whiting comes in contact with them when they are being fired, they are ruined as the whiting sinks into the enamel and sticks tight to it, rendering the surface perfectly opaque. They have, therefore, to be fired on trays in the kiln, and they come up with a bright glossy surface equal to that of the glass itself. Some two or three years ago the writer saw nearly a score of panels offered for sale as antiques in a shop in Cologne, which could be condemned at a glance for this reason alone. The English enamels are much harder, they are, therefore, more difficult to fire, and the colours are not so brilliant, but the forgers of glass are not generally aware of this fact. In seventeenth century work, such as heraldry, where the enamel has been applied thickly as it had to be, and in large and broad masses, the surface is generally covered with minute fissures and cracks caused by the co-efficient of the contraction of the enamel not being equal to that of the glass to which it has been applied. On turning the panel over and looking at the enamel through the glass, we see that it has crazed the surface of the glass like frost forms on a window pane in winter. In some places the surface of the glass has given way and the enamel chipped off, bringing the glass surface with it in the form of shell-like flakes. This form of decay looks at first sight as if it would be very difficult to imitate. Yet though I cannot say I have ever seen an example where this has been done, it is in reality very easy indeed to do, and it is well, therefore, to be on one's guard as it is quite possible that an example might turn up some day. This process of decay is exactly the same as that which is artificially produced in the form of decoration known as chipped glass, which is frequently to be seen used on plate glass in doors and so forth in modern shop fitting. The letters or ornament are left clear, whilst the ground is covered with shell-like forms on the surface of the glass itself. This is done by having the parts required to be chipped sand-blasted. White acid will not





Enamel Cracked, bringing away the surface of the Glass.

FIG. 2.—Seen from inside. FIG. 3.—Seen from outside.

do, the object being to obtain a coarse roughened surface. This having been done the whole of the glass is given a coat all over of thin strong glue and allowed to dry in the air. A second coat is then applied and when that is dry a third in like manner, and allowed to dry naturally. The sheet of glass is then placed near some hot water pipes or in front of a fire. The glue then begins to contract and on the polished surface where the sand blast has not been applied, it flakes off, leaving the glass untouched. On the roughened surface, however, it has such a hold, and the contraction is so enormous that it tears flakes out of the very substance of the glass itself, forming a shell-like surface or pattern. It is easy to see how this might be applied to the imitation of the surface of glass from which the enamel has flaked off by having the part required sand-blasted and flaking it with glue, afterwards applying enamel to the surrounding portions. As will be seen by the slide, which is a 17th century glass-painter's assay piece on which he has tried his blue enamel in order to get the right quantity of flux, the crazing of the surface of the glass where the enamel has chipped off is not always the same. Sometimes it is in large cracks and flakes as in the bottom example, at other times it appears as a fine granular or stipple effect. This latter form can be imitated by means of acid, in exactly the same way as the form of decoration, which is known as stipple acid, is produced on plates and which is frequently used in conjunction with chipped glass and white acid in order to obtain various forms of surface in embossed work. The parts not intended to be treated are coated in the usual manner with Brunswick black. The plate is then put in an acid bath of equal parts of hydrofluoric acid and water and powdered mica sprinkled all over it. The acid attacks the glass unequally, being partially prevented from doing so by the flakes of mica, and a stippled effect is produced.

TECHNIQUE OF THE PAINTING.

We now come to the important question of the technique of the painting or "handling," as it is termed in oil painting. It is safe to say in this connexion that a whole book might be written on this subject

alone, and then all would not have been said. It is, therefore, hopeless to attempt to treat of it at all thoroughly within the limits of a paper such as this and all that can be done is to lay down one or two main points of guidance. As regards mediæval glass the chief characteristic of glass of this period is the tracing. Though there was much inferior work produced it would be a matter of the utmost difficulty to imitate the freedom and the endless variety of width in the traced lines in the best old work. These sometimes vary from three-sixteenths of an inch or more in width at one end and then taper off till they end as fine as a hair. At the same time the utmost density is kept throughout. Most modern traced lines have blunt points, whilst but few modern enamels can be found which "work" well under the brush and yet keep their opacity when fired.

There is one characteristic of technique which glass of all periods from the earliest to the latest must possess, and it is this. It must never have been passed through the kiln more than once. At first sight it may seem next to impossible to prove whether this was done or not, but it can generally be determined with a tolerable amount of certainty by close examination of the high lights and lines which have been removed with the pointed end of a stick or a quill. In old work the traced lines and outlines were painted on first. The darker shadows were then washed in and removed where not wanted. Another wash was then applied to give the middle tones, and, finally, a thin wash over the whole surface of the glass, out of which the highest lights were taken with the quill or stick. In some places these have removed not only the three (or less) coats of shading colour, but the outlines as well, proving that there was nothing fired on up to that stage of the painting. One occasionally comes across cases where the stick lights pass under

Fig. 4.—Swiss Heraldic Lion.

Strokes taken out with the quill in the mane pass through both traced lines and shading, showing that the work was done at one firing.

the outlines. These, however, are not the main outlines of the drawing, but were embellishments, such as diapers, patterns, etc., which have been painted on freehand last of all.

The only exception to this rule that one is likely to meet with, is in the case where blue enamel has been applied on the back over yellow stain so as to form green. In this case the painting on the front and the yellow stain were done at one fire, and after the superfluous stain had been cleared off the blue enamel was applied and burnt at a separate fire. It is, however, always dangerous to dogmatize in these matters. I should not be at all surprised if some day an undoubtedly authentic specimen of ancient glass turned up which showed undeniable evidence of having been fired more than once and the painting carried further before the glass went into the kiln a second time. One has always to make allowances for such cases as where an artist worked in some place far removed from others of the craft, or for the work of amateurs or beginners.*

The more one studies a subject such as stained glass, not from the too frequently narrow point of view, but in all its various aspects--technical, historical or what not the less one is surprised at anything. As I recently showed, for example, in a paper read before the Society of Architects,* there is every reason to believe that the east window of St. Margaret's, Westminster, is a re-painting by an eighteenth century artist on the top of early sixteenth century work.

One other point as regards technique. All available documentary evidence proves, and the closest scrutiny of ancient work goes to show, that oil was never used as a vehicle for painting. It was all done in water from the first traced lines to the last wash. This can to some extent be proved by an examination of the strokes removed with the pointed stick or quill. The ease and facility with which they have been taken out shows that the enamel was only lightly held to the glass, whereas had oil been used the stroke would show a gummy edge, the enamel piling up in a fatty ridge of colour. Were the traced lines done in oil, this dries hard so that the quill or stick, instead of passing through them with ease, jumps over or only partially scratches a way through.

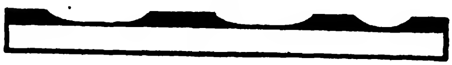
* It might be doubted that formerly there were any such persons, but history teaches us otherwise. Vide protest of the York Gild of Textwriters at the end of the fifteenth century against an amateur textwriter, a priest making books. *York Memo. Book*. Surtees Soc., Vol. II., p. lxx. Also Vasari's account of the amateur glass-painters, the Jesuati Friars taking one of William of Marseilles windows to pieces to see how it had been made, and the two Récollets, FF. Maurice Maget and Antoine Goblet, who are mentioned by Le Viell and who lived at the end of the seventeenth century, also M. Restaut, a lawyer and amateur glass-painter of the eighteenth century mentioned by the same author.

* *Journal of the Society of Architects*, April, 1922.

Abrasion.

Ruby glass has always been manufactured (and at the present day still is, except in one or two very exceptional cases) in a different way from the other coloured glasses. Instead of the sheet being coloured all through, the red lies in a thin film on the surface like the gelatine film on a photographic plate, the colourless glass beneath merely acting as a support. This peculiar method of manufacture enabled glass-painters to obtain various coloured effects on the same piece of glass by removing the red film where required and applying coloured enamels or yellow stain to the colourless glass beneath. This is nowadays done by applying a protective varnish, such as Brunswick black, to the parts which it is intended shall not be removed, and afterwards placing the glass in a bath of diluted hydro-fluoric acid which eats away the exposed portions of the red film and leaves the ground beneath. In this method the acid eats straight down, leaving the untouched portions which have been protected by the resisting varnish with perfectly

(*a*.)



(*b*.)

Fig. 5.

Ruby film on glass removed by (*a*) hydrofluoric acid and (*b*) wheel.

straight and vertical edges. It is a great temptation to the forger to use acid, on account of the speed and ease with which it can be employed, but the edges of the film should be examined and if they show that acid has been employed, the piece should be regarded with the gravest suspicion. Before the use of acid was put on a practical basis, or until a still later date when its preparation and use became common

property, the red film had to be ground away with a grindstone or with either a copper wheel or an iron instrument and some abrading material such as sand or emery. It is obvious that it is impossible by such a method to leave a sharp clean edge. The edge of the film was always either ragged or showed in section a small arc of the circumference of the wheel which had been used for grinding, and this edge had to be covered up with a traced line; otherwise, instead of there being a sharp line of division between white and colour, the one faded into the other, and the effect was blurred.

The traced line, however, does not prevent the edge being tested to see whether it is perpendicular, as it is so excessively thin. On the contrary, the depression, which is saucer shaped when the wheel has been used, can easily be felt with the finger tip. In old work it was not generally polished after being ground out, but remains rough like ground glass.

The reputed inventor of acid for eating away glass was Henry Schwanhard, who is said to have discovered it about the year 1670. Glass cutting is also said to have been invented by Caspar Lehmann, who died in 1622. As likely as not, both these artists are given far more credit than is actually due to them, and their so-called discoveries were, no doubt, little more than improvements, for an acid or "water for cutting glass" is described in the fifteenth century Bolognese MS., and Eraclius, a writer of the thirteenth century, gives a perfectly practical account of glass cutting on the wheel. Moreover, we know that the latter process was well known and regularly employed throughout the whole of the mediæval period for piercing holes in glass for the insertion of jewels and charges on shields of arms. But the case of the use of acid is different, and we must not forget that there is an enormous difference between a process which is merely in the stage of a chemical experiment in a laboratory and the same thing placed on a commercial manufacturing basis. Photography, for example, started as chemical experiments by scientists, it was next known as a secret, and finally understood and worked by all. Fluoric acid was similarly a closely guarded secret known to few in 1721, it was imperfectly described in 1725, and the correct method of producing it was not known until Scheele, the chemist, published it in 1771, whilst long after this glass painters, such as Peckitt, of York, continued the use of the wheel with which process they were more familiar. It is, therefore, necessary to be on one's guard where examples of glass painting, even after the year 1670, shew the use of acid. I have in my possession a circle which I believe is an early example of the use of acid, but such a piece is well-nigh unique.

Corrosion.

Old glass is frequently corroded. Many people think that a piece of glass cannot be old if it is not corroded or pitted; but this has nothing to do with age. Here, for example, we have two heads from the same subject, viz., the Coronation of the Blessed Virgin, in St. Helen's Church, York. The one in a bad state of decay, the other not touched. They are both of the same age and have both been subject to the same atmospheric conditions, yet the one is preserved whilst the other is in an advanced stage of decomposition on both sides. The causes of decay in glass are nowadays well understood, but this is not the time to discuss them as the whole subject has been thoroughly treated in a paper read here some time ago.* But amateurs and novices in collecting are not satisfied unless signs of at least incipient decay are present, so that the forger is prepared to supply the demand.

One form of decay to be seen in old glass is an iridescent film on the surface of the back of the glass. This can be imitated in many ways. It can be done by the method by which the articles of iridescent glass ware to be seen in the shops are produced, viz., by the deposition of metallic tin upon the surface of the glass heated in the kiln by means of the fumes of stannous chloride. But this can be detected. Actual iridescent decay by corrosion can be artificially produced by dilute hydrofluoric acid, as every glass-painter knows who has negligently left the acid bottle in too close proximity to a bin of glass. The same result can be obtained by heating the glass with hydric chloride in an hermetically sealed receptacle.

The commonest form of decay is pitting where the back of the glass is covered, to a greater or lesser degree with holes which vary from the size of a pin head to a crater half an inch or so in diameter. These holes, which before the centre actually

* Mediæval Stained Glass: Its Production and Decay. by Noel Heaton, *Journal of the Society of Arts*, No. 2834 March 15th, 1907.

FIG. 6.—Imitation 14th Century Quarry Work.

Examples of spots of colour splashed on the glass to imitate corrosion by pitting.

falls out so as to form a pit, appear as small round black spots, are imitated by "spattering." This is done by sprinting enamel on to the back of the glass by drawing the finger across the hairs of a tooth brush filled with colour, in the same way that black and white artists produce certain shaded effects in the back-grounds of their drawings. This rather crude form of imitation can be easily detected by anyone who is conversant with the process by which it has been produced. Another method of ageing frequently employed in quarry work in order to imitate the rich brown patina which most mediæval glass has, is to apply an unequal coat of brown enamel to the back of the glass, shading it darker towards the edges to imitate the dirt which collects up against the leads. Before the glass has been fired the enamel is only lightly held with gum mixed with the enamel. When this coat of enamel has been allowed to dry, the glass is lightly spattered here and there with clear water sprinkled from the hairs of the tooth brush, or by the operator spitting on it through the closed lips. The glass is again allowed to dry and is then rubbed lightly with the tips of the fingers when holes appear where the splashes of water have been, the dry colour around each spot having acted like blotting paper and sucked the gum out of the wet spots. This, whilst it gives an antique look and might deceive the unwary, would never take in anyone who has studied glass to any extent, for the result is totally unlike the effect of corrosion, which appears as dark spots on a light ground, whereas by this method the reverse is the result. Actual holes can be produced by drilling, but a microscope will at once detect the imposture. As can be seen in these examples of large pits, which are of such size that a lens is not necessary to examine them, the formation is like that of the crater of a volcano, and such an effect cannot be imitated by drilling.

Sometimes old glass has corroded, not into round holes, but into lines caused by the unequal mixing and only partial vitrification of the hard and soft materials of the glass mixture, such as sand, lime, and alkali. The resultant glass, when it has been formed into a sheet by the "crown," or whirled sheet method, consists of lines of hard and soft metal of different densities invisible to the eye, but, nevertheless, existent in the glass. The soft parts corrode, whilst the hard parts do not. The lines of corrosion generally appear as arcs of concentric circles, of which the "punty" mark (or knob of glass in the centre of the sheet by which it was attached to the "punty" or iron rod on which it was twirled during manufacture) forms the centre. This could be imitated by the use of hydrofluoric acid and a resist, such as Brunswick black, painted on the glass in imitation of the corrosion. Such a sham, if well done, would be very difficult to detect. In cases, however, where the glass has corroded in lines and not into round holes, the glass should be closely examined with a lens to determine whether it has been made as a whirled circular sheet with a knob of glass in the middle, (*i.e.*, crown) or as a cylinder slit down the side and flattened out into a rectangular sheet (muff). This can be seen by the direction of the bubbles. If these run in straight lines parallel to each other, the glass was "muff;" if, however, they are in concentric and ever-widening circles of which the knob in the middle of the sheet formed the centre, and the elongated bubbles look like ships racing round a buoy, the glass was "crown" and the lines of corrosion must follow the same direction and not, so to speak, cut across the "grain."

Crown glass, however, is rarely corroded. Being opened out from a round globe into a flat sheet by twirling as a maid twirls a mop, after having been softened by the heat of a furnace, it has not to be rubbed down on to an iron plate to flatten it and

so, as it never comes into contact with anything during the process of its manufacture as "muff" glass does, it receives a highly polished surface known as "fire finish" and this seems to help it to resist corrosion.

But though muff glass may not be actually corroded, the surface is nearly always slightly dulled.

To imitate this dulling on the back, the glass is generally given a very thin matt of black enamel. Sometimes the surface has been dulled by laying the glass on an iron or asbestos sheet in the kiln and over-firing it so that it not only is deadened, but runs into pinholes, which look like incipient corrosion. This, however, would not deceive a glass-painter, who is generally only too familiar with such accidents occurring to his work through the negligence of the kiln-man when soft glasses are being fired.

For some reason or other, which has not been as yet fully explained, the yellow stain, which is applied always to the back of the glass, protects it from corrosion, so that pitting rarely manifests itself in the parts of the glass stained yellow. If pit holes do appear they should be regarded with suspicion, as they may have been produced by spattering with paint, or the piece painted on may have been, *e.g.*, an old quarry already corroded naturally so that though the glass is old the painting on it is new.

Corrosion marks appearing in the yellow stain led to the detection of a clever forgery some time ago. Though well done, further examination showed many more of the usual characteristics. The piece was "broken" in the usual way so as to damage it as little as possible and a piece of patch inserted. The glass was too thick; it was perfectly flat on the back without any cockling, and had a bright and highly polished surface, but the bubbles showed that the glass was muff, not crown. The brown enamel was heavily fluxed and had fired down very snug to a bright, shiny surface, and was very transparent, pointing to the use of foreign enamel and a modern gas-kiln, where the glass is fired face up and a single tray at a time, not buried in whiting in a pan as the ancient practice was. The glass had not been outlined first and afterwards shaded, but the reverse process adopted, for the stick-lights passed *under* the outlines in several places. Lastly, the corrosion appeared on the *front* and not on the back and under a lens showed as black dots grouped in a regular pattern of six or eight together in small square patches, showing that they were produced by some artificial method.

Swiss Glass.

Nowadays there is no glass so much sought after as Swiss panes. Unfortunately, there is only so much of this to go round, and practically all the best pieces have long ago passed into public or private collections, so that if a piece does come into the market it is instantly snapped up at a high price. This has led to a large number of forgeries of Continental origin appearing in antique dealers' shops and in auction rooms, the manufacture of these amounting to almost a small industry. The skill, however misapplied, with which these are executed is amazing, and the knowledge and study of old work which has gone to the making of them is surprising. Some have even found their way into national collections, so that it is hopeless for the amateur to try to detect the good from the bad, as this will often tax the wits of the greatest experts. One of the most skilful of these forgers is at Düsseldorf. Such men are the cream of a shady profession, and like the swell cracksmen, are after big things and high prices for their work. No amount of pains or trouble must be spared, and they must moreover possess an extraordinary degree of skill in technique and craftsmanship. Naturally enough, a man who was particularly good at imitating Swiss work would be hopelessly at sea with that of the 14th century, but by confining themselves to the glass of one period, forgers become extremely clever at imitating it.

It is, therefore, very difficult to lay down any hard and fast rules, and the safest guide is judgment founded on the continual inspection and handling of Swiss glass. Unfortunately, the opportunities for doing this are not very frequent, but I have been particularly fortunate in this respect, as at an early age I was brought into close contact with one of the largest private collections of Swiss glass in the world, consisting of between four and five hundred pieces, which my father was engaged upon in arranging, classifying and re-leading for many years. Whilst it is impossible to treat the fascinating subject of Swiss technique and craftsmanship within the

limits of a paper such as this, the following points should be noted :—

The glass should be extremely thin—as thin as that of the specially thin glass upon which the gelatine film of plates intended to be used in the sheaths of hand cameras is coated. Though it is always dangerous to dogmatize in these matters it may, as a general rule, be laid down that the enamel must be absolutely black when seen by reflected light, not brown or purplish, it must also be quite dull on the surface. An enamel which has fired up to a bright glossy surface as most of the modern foreign enamels do, should be at once rejected. The coloured enamels are all applied thinly, excepting the blue. This has been floated on thickly, probably with a spoon and in a very liquid condition, so that it is frequently "staddled," the enamel tending to collect into spots round some particle of enamel larger than the others. When required in small patches it has been applied to a larger surface than that of the robe or what not which it was required to tint, and the superfluous enamel cleared away with a stick, leaving the edge of the coat of enamel standing up with a sharp clear edge as thick as a couple of visiting cards. The blue generally fired with an eggshell gloss, neither perfectly dull nor very bright and shiny.

In Swiss panes the quill work or strokes where the enamel has been removed to form high lights in grass, diaper patterns, etc., is wonderful. Although in many German reproductions this is very well done, it requires extraordinary dexterity of hand and the forgery is very frequently far inferior to ancient work. In some cases it is very badly done. If we compare the treatment of the grass in this subject of "Wildfowling" with the treatment of the foreground in this forged circle the difference between the two will be at once seen. In the trees one sometimes sees examples where touches of paint have been applied to the glass to show separate leaves or tufts of leaves, as in water colour painting on paper. But old work was not done that way. A few traced lines were first applied in the manner of the wood cuts of that period, a wash of enamel was applied to represent the darkest parts and then a flat wash over all, the enamel which had overspread the tree and covered the sky being cleared away, and leaving the tree flat. A few lights were afterwards removed to give the light portions of tufts, etc.

In the architecture at the sides of the panels the lines on the edge of mouldings etc., are in the best old work absolutely straight and parallel and at perfect right angles to each other. This shows that the glass was fixed up on an easel formed of a sheet of glass in a perfectly rectangular wooden frame upon the edge of which a T square could be used as in a drawing board. The glass was waxed up in the usual manner and the lines where scratched out with the pointed end of the stick or the quill pen were, therefore, perfectly straight and square. Indeed, Jost Amman, who as one of the most prolific designers for Swiss glass who ever lived, was, therefore, in a position to know, shows such an arrangement in his wood-cut of a glass-painter at work. Genuine examples where the lines are not perfectly straight and regular, but which have been done free-hand, can be found. They are, no doubt, the work of learners or inferior artists, but, on the other hand, such work is more frequently an indication of the work of an imitator.

In imitations one also frequently sees the technique of the painting of the drapery differs from that to be seen in the best old examples. The operator was fully aware that instead of removing the colour to form the lights with short brushes, the old artists employed nothing but a stick or a quill, but the way in which these implements have been used is incorrect. Long, straight strokes have been scratched out along the length of the folds of drapery, but that was not the method of handling usually employed. If we examine a piece of actual old work closely we see that the lights were taken out in a mass of curly, scribbly lines, which as the lights recede into the shadows give place to a series of dots gradually diminishing in size.

The treatment of the diaper patterns on the backgrounds in Swiss work is very characteristic and they should be carefully examined. Very frequently a stencil * has been employed.

* Stencils are mentioned in a MS. on glass-painting of the XVIth century, printed by L'Abbé Texier, in his Histoire de la Peinture sur Verre en Limousin, 1847, p. 107, as follows :—" Et, pour égayer davantage. . . . avec un cuivre ajusté pour afréger, tu traceras dans la conduite des creux (du cuivre) ornements et rinceaux comme jaillissant de vases, et se reliant ou bien formant couronne et bouquets enlacés." The Abbé Texier remarks :—" A la vue des mêmes ornements répétés sur des verres de couleurs différentes, nous avions soupconné que le trait si coulant et si pur des ornements de cette époque peints sur les vitraux était dû trop souvent à un procédé mécanique. La publication de ce fragment ne peut laisser de doute à cet égard "

FIG. 7.—Swiss Glass.
Diaper Background Stencilled.

As is always the case with such makeshifts, the pattern when done mechanically never fits and is always too large or too small for its place, and how the old artists could tolerate such rubbish surrounded as it was with work done with the most infinite zest and the most excellent fancy, I can never understand. But there it is, and the fact has to be accepted. Yet though the forger may be perfectly aware that stencils were formerly employed, and he therefore employs one also, he is not always careful to use it in the old way. For nowadays in stencilling on glass—which I blush to admit is still done, especially in the United States and by men who claim to be "art craftsmen"—the glass is first painted with a flat coat of enamel and the stencil laid over it. The paint seen through the holes is then removed with a tooth brush passed quickly over it. By this method the result is never sharp and clean, especially where an old stencil has been used which has become twisted and bent and does not lie flat on the glass. But old work was not done that way, as a close examination shows. The stencil was evidently laid on the glass as before, and a pointed stick or quill passed round each hole in exactly the same way as a glazier cleans away the superfluous cement which collects up against the leads when cementing a light. The ground of the pattern was then cleaned out by hand with a brush. By this method the amount of time saved, if any, would be very slight and the result not worth the small amount of pains taken.

One word in conclusion. It is a great mistake to get into the habit of suspecting everything one sees, like a child who imagines there is a bear lurking in every dark corner on the way to bed, and this is an attitude of mind to which "experts" are very prone, so that eventually they

come to suspect their own shadows. A little common sense is often a more reliable and trustworthy guide than an opinion which has to be paid for. It is obvious that a man will not go to ten times the amount of trouble to fake a piece in order that it may pass as old, when he could do a new one in half the time, unless he is going to be well paid for his trouble, so that pieces which are offered at a reasonable figure are generally either perfectly genuine or of the class of obvious shams which are turned out by scores and by hundreds. For example, I have pieces of 13th century grisaille, and circles of 16th and 17th century workmanship which cost less than £2 each and were exposed for sale in shops in Paris, where anyone who was lucky enough could have picked them up. On the other hand, I have seen stocks of similar circles and squares in antique shops in Cologne the products of factories which make a business of it, offered for a few shillings each. In neither case was it necessary to exercise expert knowledge to know that the one was as obviously genuine as the other was transparently the reverse.

DISCUSSION.

The Chairman (Mr. Bernard Rackham), in opening the discussion, said the subject of Mr. Knowles's paper was of the very greatest importance to all those who loved old stained glass, and more particularly to those—and there was an increasing number of them—who collected stained glass, whether on their own account, or as trustees of National collections. There were several points which Mr. Knowles had mentioned which had suggested themselves to him as being of special interest, particularly that of the uneven action of corrosion; an example of which had been shown on a slide representing the Virgin and the figure of Christ. There was at South Kensington a very charming little panel of the Virgin sitting on a bench in the open air which, in the past, had puzzled him very much. The explanation of his puzzlement had been afforded him some time ago by the late Maurice Drake. He desired to take the opportunity of saying that Maurice Drake's death had been a very serious loss to all those who were interested in stained glass. Nobody had a more sympathetic understanding of the art, and a greater love for it than Maurice Drake. Maurice Drake had pointed out to him that it was quite possible that the panel in question might have been unevenly subjected to the action of moisture. The upper part of the panel was perfectly clear; the glass was beautifully smooth, and there was not a trace of decay or corrosion in it at all. The lower part, on the other hand, was badly pitted with corrosion. It was a very strange thing to see, but it could be explained, he thought, by the fact that, by some accident, the lower part had been exposed to the weather, and the upper part had been protected from it.

With regard to the question of glass, he had been shown the other day a representation of some small heads brought from a small village in Normandy, which purported to be of the Thirteenth Century. They were of the Thirteenth Century, but not wholly so. The glass was undoubtedly the ordinary pinkish glass of thick composition which was universally used in the early Thirteenth Century to represent the flesh portions of the figure, but the features painted on the glass were certainly not original. The point was that there was in existence glass which was completely forged glass, but there was a much more dangerous class of forgery, namely, that of which half was composed of the original material but in which the painting and the pattern were not so composed.

There was another point which deserved consideration. It was obvious that stained glass windows must have been subject, if not to forgery, at least to modification. Ever since the day when it had first been made, a Thirteenth Century window was bound, in the course of time, to get broken by some accident or another. A hole occurred in it, and it had to be filled with glass of the period at the time the accident occurred. There must be many stained glass windows, additions to which had had to be made. They were not forgeries, but modifications and additions, which might have happened at any time subsequent to the original erection of the window. That would account for some very puzzling phenomena which were occasionally seen. For instance, Mr. Knowles had shown him some time ago an instance of that in the celebrated East window at St. Margaret's Church, Westminster, which was a very fine interesting piece of work of the Sixteenth Century, but which had been modified at a later date—in all probability at the time when the window had been erected at Westminster. That window showed a great quantity of dusky enamel, which was quite foreign to the style of the period when the original window had been made.

He might mention that at the Victoria and Albert Museum they had not only the glass which was exhibited to the public, but also a collection of small pieces of glass which were too small to be exhibited, but which would be of the greatest interest to all students who desired to come to close quarters with the subject of glass technique. He was glad to have the opportunity of making that announcement because, after all, it was the desire of those in authority at South Kensington, that the collections there should be made as useful as possible. Therefore, if those who loved, and made a study of, stained glass desired to take the advantage of seeing those small specimens at the Museum, they would be heartily welcomed there.

MR. NOËL HEATON expressed his appreciation of the paper and congratulated Mr. Knowles on breaking new ground in explaining the difference between genuine and forged stained glass. It must have been an extremely difficult task to collect all the evidence which Mr. Knowles had produced that night. The author had begun by explaining the difference between a reproduction of old glass and a forgery of old glass. It seemed to him (the speaker) that the line between the two was a very finely drawn one, and he was afraid, in some cases, one might merge into the other. He had not the slightest doubt that in some cases old glass might have been copied for quite honest and genuine purposes but that it had subsequently got into the hands of other people, who, either in ignorance or otherwise, had passed it on as the genuine thing, and therefore what had been orginally an honest reproduction, had passed into the category of a forgery.

There were some who went as far as to say that any sort of reproduction of old work was to be deplored—that when a man restored ancient stained glass which had been damaged, he should not in any case reproduce the original design but leave blank any bits that had been broken out, or at most mat them over so that there should be no mistaking the old and new work. Personally he confessed that he could not altogether approve that idea. He thought reproduction, as long as it was clearly understood that it was reproduction, was all to the good. When reproductions were very well done, in some cases one could easily be deceived by them. He frankly confessed that he had been deceived in that way quite recently by the East window at Auxerre Cathedral. He had begun admiring it as a magnificent example of Thirteenth Century work until, on closer inspection, he began to see the details of the design, and finally he discovered from the guide book that the window had been blown out by a shell in the Franco-German war, so that it could not have been original Thirteenth Century glass.

There were one or two points of detail on which he did not altogether agree with Mr. Knowles—for instance, on the point of thickness of ancient glass. Mr. Knowles had said that mediæval glass was always thinner than modern glass. That held good to any time back to the Fourteenth Century, but surely it did not apply to the very earliest glass, particularly to the early Thirteenth Century. Surely one got there a glass which was characteristically thick, and of uneven thickness, and always in small pieces ? He did not think a piece of early Thirteenth Century glass would ever be found which was more than four or five inches long and two or three inches wide. He ascribed that to just the reverse reason to that which Mr. Knowles gave—and which was perfectly correct in regard to later glass. In those early days people could not make the glass thin, because it was more difficult to get it thin than it was to make it thick. In order for glass to be made into thin sheets it had to be pretty fluid and easily blown. In those early days the furnaces were very imperfect ; the glass could not be brought easily to a state of great fluidity. Also it was a glass which was of a very stodgy nature. They could not gather very much on the rod ; consequently, they got very small and very thick pieces. Later on, as their technical skill grew, they obtained the characteristic thin glass to which Mr. Knowles had referred.

The author had also said very definitely that one never found "foxiness" in the enamel of old glass. He admitted it was very uncommon to do so, but he had seen several examples of certainly genuine stained glass of about the latter half of the Sixteenth Century where that "foxy" colour of the enamel had been quite distinct. He would like to emphasise what had been said as to the enamel or "colour" used in mediæval times never being fired to a glossy surface. This was perfectly true and it was rather an important point from the technical point of view. There was a belief amongst modern glass painters that the enamel could not be permanent unless it was fired to a varnish surface. As a matter of fact, the more fusible and less durable the enamel was the more readily it gave this high gloss. In mediæval times they used an enamel actually harder than the glass and so loaded it with pigment that it fired dead and that was why they could obtain that strength in the fine lines which Mr. Knowles had demonstrated. If one were to offer an enamel of that type to a modern glass painter, he would not use it.

Mr. Knowles had described various ways in which corrosion could be imitated, and had pointed out that those imitations could very easily be detected. He had further said that actually to reproduce genuine corrosion was a thing that could not be done. That was generally admitted to be the case —so much so that it was very often considered the most reliable test of genuineness ; he (the speaker) considered that it was quite practicable to produce genuine corrosion by artificial means. This was a very different thing from trying to imitate the effect of corrosion in the various ways described in the paper. Some years ago he had been investigating the causes of the peculiar pitting which took place in glass. There had been a controversy for a long time between those who said this was purely a question of the composition of the glass and those who said that it was due to the action of the growth of certain minute forms of vegetation on the surface of the glass. He claimed that it was entirely a chemical and physical matter. If this theory were correct it should be possible to produce the corrosion artificially if one had sufficient scientific training to carry out the necessary operations. To prove his theory he had set to work, and had actually corroded glass artificially. It was not altogether easy, but it was not a matter of extreme difficulty if one knew the way. He had never published or said anything about the matter up to the present moment, because if it became generally known how glass could be artificially corroded, a very potent weapon would be put into the hands of the forgers. By ageing the glass in the particular way which he had discovered, he

would back himself to produce specimens of "'ancient stained glass" which would deceive Mr. Knowles himself.

Finally, on the question of the uneven resistance of glass to corrosion, he endorsed the remarks made by Mr. Knowles. He ascribed the variation of durability to a combination of two or three circumstances. One was the unequal exposure to the weather; another was the difference in the composition of the glass; it was quite easy to see how one could get differences of composition even in the same window; and the third was the way in which the glass had been fired. The firing of glass in mediæval times was very crude and irregular. If one put those three circumstances together, one could easily understand that the resistance to corrosion in glass would vary very considerably. The same thing happened even at the present time. He knew of one case where, even in recent years, in a window which was otherwise perfectly sound, one or two pieces had absolutely gone to ruin already. That was because a particular kind of glass had been used which had been badly made. If that sort of thing could happen in the present day, when technical knowledge in the trade was so great, one could well imagine that the composition in mediæval times might vary to such an extent as to account for the extreme differences which were found.

Dr. T. M. Legge, C.B.E., said the only point at which he found himself at variance with Mr. Knowles was when he said that corrosion always appeared black against the glass. Personally he knew a window of St. Margaret spearing a dragon of Fifteenth Century workmanship, in which the dragon's wings were blue with yellow stain so as to make it greenish, and the ribs in the wings and the spots were all originally in black enamel. Those had been the lines and the particular points on which corrosion occurred. They had all disappeared, so that now there were white lines against the green where formerly there had been black.

Mr. F. S. Eden said there was one point on which he would like to make a few remarks, namely, upon the difference between forgeries and honest reproductions. He had had considerable experience of both, and it had occurred to him that it would be a very good thing indeed if some system could be devised which could be, he would not say universally but at least in this country, adopted for reproductions. So long as there were expert men doing the work in exactly the same way as the workers of the Middle ages did it, so long would there be the danger of so exact a reproduction that it might, in the eyes of the many, amount to a forgery. As Mr. Noël Heaton had pointed out, even if it had been originally an honest reproduction, in the course of time the reproducer died, his executors came into possession of the glass, sold it by auction, and, perfectly honestly, sold it as ancient glass. So long as that sort of thing went on it would depend entirely upon the ability of the original painter as to whether it should be ultimately accepted as an honest reproduction or as a forgery. He suggested that reproductions should be made by some vehicle which could be easily detected by the expert, but which, nevertheless, gave a fairly good representation of the work which it was supposed to represent. All glass painters, and most literary men who dabbled in the subject, knew that in the Fourteenth Century artists painted in varnish colours on white glass, in somewhat the same way as, since the Sixteenth Century, glass painters had painted with colour enamels, but that varnish painted glass was not fired. It gave, at first sight, when put in the window, a fairly good representation of the subject it was supposed to represent, but if an expert looked at it he knew what it was at once. There was no possible question of deceit, and at no time could it ever be put up for sale as a piece of genuine work. If only that plan could be adopted at the present time, it would solve the whole question of forgeries. Nobody, he supposed, had seen more of genuine glass and forged glass than himself, and he quite admitted that he had been over and over again deceived. On many occasions he had at first sight thought that reproductions had been ancient work, simply owing to the extreme ability of the modern painter. If there was some medium of translating old glass to modern folk in a form that could not be mistaken by experts for ancient work there would be no more trouble.

Mr. Walter Tower remarked that no mention had been made in the paper about the date of forgeries. He enquired whether Mr. Knowles could state what was the earliest known forgery. He imagined himself that most forgeries began about one hundred years ago, but if there were known forgeries earlier than that, it would be interesting to hear of them.

One point which had struck him was that in connection with corrosion, Mr. Knowles had stated that the pit holes nearly always stopped when they came next to stain; that was to say, the stain acted as a kind of protection against the corrosion. One had often seen cases where the pit holes seemed to skirt the edge of the stain in a very decided way, but, on the other hand, one had seen exactly the contrary of that, where the pit holes had gone across the stain. That was rather an interesting point, the explanation of which might be that given by Mr. Heaton, who had said that it had to do either with the manufacture and quality of the original glass, or the nature of the firing: that being the reason why corrosion had stronger effects on some pieces of glass than it had on others. Whether that was the reason why pit holes stopped against stain he was not personally prepared to say, but he would like to have the author's opinion on the point.

MR. F. C. EELES gave instances of certain forgeries which he had come across, and said that he felt it was really essential that there should be some way by which, on close examination, one could detect what was old work and what was new. in cases where anything of the nature of reproduction was held to be desirable. With regard to the thickness of old glass, he knew of cases of undoubted Fifteenth Century glass where, in the same window, the glass in some parts was very thick indeed, and in other parts was of extreme thinness. The instance of the Sherborne glass mentioned in "The Times" that day, showed that there could be a very great variation in the thickness of the glass in the same window of the same date. Again, in some Kentish glass which he had been handling recently, the glass in the tracery of Fifteenth Century windows was really very thick—as thick as Thirteenth Century glass—whereas, in the same window for the glass in the main lights, the glass-makers of the period seemed to have selected about the thinnest glass they could find.

MR. KNOWLES, in reply, said in regard to those cases where the glass was old and the painting new, that was an instance where half a truth was ever the blackest of lies; and unfortunately, such things were very frequently done.

With regard to Mr. Noël Heaton's point about thickness, he had not the slightest doubt that Mr. Heaton was right. He would also not attempt to argue with Mr. Heaton on the other points he had raised, because Mr. Heaton had made himself an expert on the subject of corrosion.

He did not know when the earliest forging took place, but it could not have been very long ago. When the collections of Swiss glass were brought to England, one could have had the glass for the asking. Nobody thought anything of it. It was only quite recently that old glass had been thought much of. Horace Walpole told how he sent an Italian to the Continent who fetched back 450 pieces, for which, and for the expenses of the journey he paid only thirty-six guineas. Therefore, forgery must be quite a modern thing.

With regard to the difference between a forgery and a reproduction, he could see no good at all in making a copy of anything excepting for educational purposes for the Museums, and so forth; but there must be the very greatest temptation for a man who became clever in making such things to make small pieces which could easily be sold and deceive people. It perhaps might be a good thing if the British Society of Master Glass Painters devised some rules with which everyone of their members who made a copy had to comply, in order to prevent any mistake.

With regard to stain protecting the glass from corrosion, the yellow stain very frequently did that. He did not say that corrosion was never seen where the stain had been applied, but he did say it was very rare to see it.

MR. A. A. UPJOHN (Master of the Glaziers' Company), in moving a hearty vote of thanks to Mr. Knowles for his paper, said all those present were lovers of paintings on glass, and as such it had been of great interest to them to listen to the paper which had been read by Mr. Knowles, who was the great master glass painter of York. Mr. Knowles was not only well known in York, but throughout the whole of the kingdom, as an authority on the subject. It was clear that Mr Knowles had been reared on glass, and that the great city of York which contained so much old painting on glass had been a great field for him. He was sure those present were greatly indebted to Mr. Knowles for the amount of time and thought he must have given in the preparation of the paper, and he would ask them to give him a very hearty vote of thanks.

The vote of thanks was then put and carried unanimously, and the meeting terminated.

MR. G. WÜTHRICH, M.I.E.E., writes: When I am on the eve of a new panel acquisition, I naturally ensure that the "leading" is of the right mould, and that the dust of lead oxidation is not overdone—that is, of course, if the lead is supposed to be contemporary. The glass must be of the correct texture, tint and thickness, and, above all, of the epoch corresponding with the heraldic and architectural design, and the production and application of the enamels and stains used; the grinding off of "flashing" must be "hard" and not "soapy," "washy" and acid borne; the corrosion pits must be of the right shape and correctly edged, not "tooled" or "acid etched." The cracks in repaired panels, if made good, must be "bridged" and not "filled," otherwise the panel must be deformed and wider by the total thickness of all the lead fissures inserted. The caligraphy of the dates, must be strictly of the correct period, and there must be no "halo" coming from the grinding out of figures, especially the century numeral in. say, 1682, which the forger very much likes to change into a 5, making it 1582; thus pre-supposing that the discrepancy between the heraldic or ornamental features and the new "old period" will escape the eye of the innocent collector.

The perusal of Mr. Knowles' paper demonstrates that there are a hundred and one things which must be observed to ensure protection against the craftmanship of the forger. He is only too right in stating that the modern forger does not frequently operate so clumsily; the forger is an expert craftsman incarnate, and I am afraid that the only real protection against his handiwork lies in that flair, instinct and touch which comes from the sad contemplation of many and costly errors. Much more reliable than the application of text books and rule of thumb methods is the advice of an expert such as Mr. Knowles, or, in Swiss stained panels, of Dr. H. Lehmann, Director

of the Swiss National Museum of Zürich. Then one can enjoy the consciousness of possessing "the real goods," and need not suffer under the stealthy uneasiness that is inseparable from half-knowledge.

The modern forger should be fought tooth and nail. Collectors should sink their bashfulness and assist potential buyers and art experts in ruthlessly bringing the malefactors to book. Art Societies should organise and combine in stamping out this pest.

CORRESPONDENCE.

EXHIBITIONS.

In his fascinationg address on "Exhibitions," Lord Askwith enumerated several of the "material results" we owe to the Great Exhibition of 1851.

There was, however, one that he did not mention which might be commended to the careful consideration of the authorities of the British Empire Exhibition of 1924, as worthy of imitation. I refer to the Science Research Scholarships (including the later Industrial Bursaries) which are provided out of funds derived from the 1851 Exhibition. That scheme affords opportunities for research to students from all parts of the Empire and the list includes several who have made notable additions to knowledge in recent times. Many have subsequently been engaged in industry and thus the scheme has aroused public opinion to an appreciation of the value of applying science to industry.

This aspect of the subject is peculiarly appropriate to the moment, when a drastic change in fiscal policy is suggested as a solution of the problem of unemployment, to a country whose industrial history is full of examples of new fields of productiveness and employment which have been opened up by the application of the results of pure scientific investigation.

WALTER C. HANCOCK.

Imperial College of Science and Technology.
South Kensington,
London, S.W.7.
November 29, 1923.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evening, at 8 o'clock:—

DECEMBER 12.—SIR FRANK BAINES, C.B.E., M.V.O., Director of Works, H.M. Office of Works, "The Preservation of Historic Buildings and Ancient Monuments." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., will preside.

INDIAN SECTION.

Friday afternoon, at 4.30 o'clock.

DECEMBER 7.—WILLIAM FOSTER, C.I.E., Historiographer, India Office, "The Archives of the Honourable East India Company." (Sir George Birdwood Memorial Lecture.) THE Rt. HON. VISCOUNT PEEL, G.B.E., Secretary of State for India, will preside.

DOMINIONS AND COLONIES SECTION.

Monday afternoon, at 4.30 o'clock.

DECEMBER 17.—WM. C. NOXON, Agent-General for Ontario, "Empire Settlement." The EARL OF AIRLIE, M.C., will preside.

PAPERS TO BE READ AFTER CHRISTMAS.

G. ALBERT SMITH, "Cinematography in Natural Colours—further developments" (with illustrations—scenes from H.R.H. The Prince of Wales's Tour in India).

IYEMASA TOKUGAWA, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

SIR RICHARD ARTHUR SURTEES PAGET, Bt., "Fused Silica and its use as a Refractory Material."

H. MAXWELL-LEFROY, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., will preside.

PERCIVAL JAMES BURGESS, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber."

CHARLES S. MYERS, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation."

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, "Recollections

of some Notable Scientific Men." (Illustrated by Photographs.)

SIR RICHARD M. DANE, K.C.I.E., Commissioner North India, Salt Revenue, 1898-1907; Foreign Chief Inspector, Salt Revenue, China, 1913-18, "Salt Manufacture in India and China."

BRIGADIER-GENERAL HENRY ALFRED YOUNG, C.I.E., C.B.E., late R.A., Director of Ordnance Factories, India, 1917-21, "The Indian Ordnance Factories and Indian Industries."

JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

COLONEL H. L. CROSTHWAIT, C.I.E., R.E., retd., late Superintendent, Survey of India, "The Survey of India." Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., Rector, Imperial College of Science and Technology, will preside.

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

F. W. WALKER, "The Commercial Future of the Backward Races, with Special Reference to Papua." SIR GEORGE R. LE HUNTE, G.C.M.G., will preside.

THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

January 4, 18, February 15, March 21, May 2.

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock.

February 5, March 4, April 1, May 27.

CANTOR LECTURES.

Monday evenings, at 8 o'clock.

ALDRED F. BARKER, M.Sc., Professor of Textile Industries, The University, Leeds, "Recent Progress in the Wool Industries." Two Lectures. December 3, 10.

SYLLABUS.

LECTURE II.—December 10th. Processes:—Brief review of developments of the past hundred years. Basic principles revealed by this review. Recent improvements in the principles of manipulation of the raw materials. Recent mechanical developments. Prospective manipulative and mechanical developments. Distribution of the Industry:—The present distribution and the principles of distribution involved. Prospective distribution.

ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." Three Lectures. January 21, 28; February 4.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

COBB LECTURES.

Monday evenings, at 8 o'clock.

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures March 24, 31; April 7.

DR. MANN JUVENILE LECTURES.

(*Special tickets are required for these Lectures*).

Wednesday afternoons, at 3 o'clock.

DR. WILLIAM ARTHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology. "Fire and Explosions." Two Lectures. January 2, 9. The Lectures will be fully illustrated with experiments.

MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, "Among the Selkirk Mountains of Canada (with ice-axe and camera)." One Lecture. January 16. The Lecture will be fully illustrated with hand-painted lantern slides.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, DECEMBER 10..Geographical Society, Lowther Lodge, Kensington Gate, S.W., 5 p.m. Dr. A. T. Doodson, "The Work of the Liverpool Tidal Institute."

Swiney Lecture, King's College, Strand, W.C., 5.30 p.m. Dr. W. T. Gordon, "Gem Minerals and Their Uses in Art and Industry." (Lecture X.)

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m.

Farmers' Club, at the Royal United Service Institution, Whitehall, S.W., 6 p.m. Annual Meeting. Mr. A. Mansell, "The Influence of Pedigree on the Ordinary Farming Stock of the Country."

Metals, Institute of (Scottish Section), 39, Elmbank Crescent, Glasgow, 7.30 p.m. Mr. A. T. Adam, "Cold Working of Metals and its Influence on the Properties and Uses."

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Mr. W. Dale,

"Egypt in the days of Akhenaten and Tutankhamen."

TUESDAY, DECEMBER 11..Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. L. R. McCollum, "Modern Rotary Drilling Systems."

Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C. 8 p.m. Messrs. G. Herbert and R. A. Ives, "Some Applications of Illuminating Engineering in Practice."

University of London, University College, Gower Street, W.C., 5.30 p.m. Baron A. F. Meyendorff, "Legislative Procedure in Russia before 1905."

5.30 p.m. Miss H. D. Oakeley, "The Roots of Early Greek Philosophy." (Lecture III.)

5.30 p.m. Professor H. C. H. Carpenter, "Metallic Crystals and Their Properties." (Lecture II.)

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Sir William Vincent, "British Rule in India—What it has achieved."

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Discussion on Mr. Blocksidge's paper, "Life Saving Appliances on Cargo Passenger Steamers."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. "The Dusun of British North Borneo."

Metals, Institute of (Birmingham Section), Chamber of Commerce, New Street, Birmingham, 7 p.m. Major R. M. Sheppard, "Extension Problems."

(N.E. Coast Section), Armstrong College, Newcastle-on-Tyne, 7.30 p.m. Messrs. S. G. Homfray and J. Adam, "Admiralty Gun Metal."

Transport, Institute of, at the Institution of Electrical Engineers, Victoria Embankment, W.C. (Graduate Section). Mr. C. Anderson, "Ministry of Transport Requirements with Reference to Railway Companies."

Master Glass Painters, British Society of, in the Lecture Theatre, Victoria and Albert Museum, South Kensington, S.W., 3.30 p.m. Dr. M. R. James, "The Eton Wall Paintings: Their Relation to Stained Glass and other forms of Art."

WEDNESDAY, DECEMBER 12..African Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. C. F. Rea, "The Arussi and other Galla of Abyssinia."

University of London, Westfield College, Hampstead, N.W., 5.15 p.m. Professor Craigie, "The Making of a Dictionary."

United Service Institution, Whitehall, S.W., 3 p.m. Wing Commander C. H. K. Edmonds, "Air Strategy."

British Decorators, Institute of, Huddersfield, 7.30 p.m. Mr. W. H. Cantrill, "A Pilgrimage to the Hill Towns of Umbria."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. B. H. Morgan, "The Work of the Imperial Economic Conference."

Civil Engineers, Institution of, Great George Street, S.W., 7 p.m. (Informal Meeting.) Messrs. W. P. F. Fanghaenel and W. N. Booth, "The Lighting of Factories."

Mechanical Engineers, Institution of, Cardiff, 7.30 p.m. Mr. H. D. Madden, "Mechanical Engineering in Modern Gas Works."

Swiney Lecture, King's College, Strand, W.C., 5.30 p.m. Dr. W. T. Gordon, "Gem Minerals and Their Uses in Art and Industry." (Lecture XI.)

Transport, Institute of (N. Western Section), The University, Liverpool. Mr. R. D. Holt, "Ocean Transport."

Textile Institute, St. Mary's Parsonage, Manchester. Mr. E. C. Barton, "Decimal Progress."

Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., 6.30 p.m. Mr. H. D. Nickinson, "Some Experiments in the Lubrication of Commercial Vehicle Engines."

THURSDAY, DECEMBER 13..Engineering Inspection, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Mr. W. Allsup, "Gauging, Gauge Design and Inspection."

University of London, at the London School of Economics, Houghton Street, Aldwych, W.C., 5.30 p.m. Mr. H. H. Gordon, "The Financial and Municipal Problem of London Traffic."

6 p.m. Mr. J. Lee, "Public Administration from Within—The Psychology of Communication."

At the Royal College of Surgeons, Lincoln's Inn Fields, W.C., 4 p.m. Mr. F. W. Twort, "The Influence of Environment on the Life of Bacteria."

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Linnean Society, Burlington House, Piccadilly, W., 5 p.m.

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. J. H. Sexton, "Fresco Painting."

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Miss Kate Stevens, "My Trip Round the World."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. Mr. D. Brownlie, "Pulverized Fuel and Efficient Steam Generation."

Metals, Institute of, at the Institute of Marine Engineers, 85, The Minories, E., 8 p.m. Mr. A. H. Mundey, "Some Foundry Problems" (Joint Meeting with the Institution of British Foundrymen.)

Literature, Society of, 2, Bloomsbury Square, W.C., 5.15 p.m.

Historical Society, 22, Russell Square, W.C., 5 p.m. Miss R. Graham, "The English Province of the Order of Cluny in the 15th Century."

Central Asian Society, at the Royal United Service Institution, Whitehall, 5 p.m. Capt. F. K. Ward, "Eastern Tibet and Yunnan."

Tropical Medicine and Hygiene, Royal Society of, Endsleigh Gardens, N.W., 8.15 p.m Laboratory Meeting.

Constructive Birth Control and Racial Progress, Society for, at Essex Hall, Strand, W.C., 8 p.m. Prof. E. W. McBride, "The Inheritance of Mental Defects."

FRIDAY, DECEMBER 14..London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. A. T. Edwards, "Good and Bad Manners in London Architecture."

Aeronautical Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m. Mr. W. Loth (of Paris), "Leader Cables for Electrical Steering of Aeroplanes."

Metals, Institute of (Local Section), The University, Sheffield, 7.30 p.m. Mr. J. H. G. Monypenny, "The Metallurgical Microscope—some notes on its Construction and Use."

At the University College, Singleton Park, Swansea, 7.15 p.m. Mr. A. L. Norbury, Some Applications of the Brinell Hardness Test."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Professor A. H. Gibson and Mr. H. W. Baker, "Exhaust Valve and Cylinder Head Temperatures in High Speed Petrol Engines."

University of London, University College, Gower Street, W.C., 5.30 p.m. Professor A. B. Charlton, "The Dark Comedies of Shakespeare."

Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.

Medical Officers of Health, Society of, 1, Upper Montague Street, W.C., 5 p.m. Dr. H. Scurfield, "On Lines of Advance in Maternity and Child Welfare Work."

Sanitary Institute, 90, Buckingham Palace Road, S.W., 3 p.m. Conference on "Tuberculosis in Cattle and the desirability of Allowing the Introduction of Breeding Heifers from Canada of Certified free from Tuberculosis."

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Swiney Lecture, King's College, Strand, W.C., 5.30 p.m. Dr. W. T. Gordon, "Gem Minerals and Their Uses in Art and Industry." (Lecture XII.)

SATURDAY, DECEMBER 15..London County Council, at the Horniman Museum, London Road, Forest Hill, S.E., 3.30 p.m.

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FRIDAY, DECEMBER 14, 1923.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, DECEMBER 17th, at 4.30 p.m. (Dominions and Colonies Section.) WM. C. NOXON, Agent-General for Ontario, "Empire Settlement." THE EARL OF AIRLIE, M.C., will preside.

FIFTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 5th, 1923; PROFESSOR CHARLES ALBERT SEWARD, M.A., F.R.S., Professor of Botany in the University of Cambridge, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Clark, John Murray, LL.D., K.C., Toronto, Ontario, Canada.
Cullen, Jos. F., Salt Lake City, Utah, U.S.A.,
Goode, Clarence S., M.Inst.R.E., Hinckley.
Hibberd, Reginald James, M.Inst.R.E., Haslemere, Surrey.
Keith, Charles, Kansas City, U.S.A.
Ledigard, Edgar M., Salt Lake City, Utah, U.S.A.
Life, Professor Frank M., Tucson, Arizona, U.S.A.
Manekshaw, F. H., London.
Mitra, S. B., London.
Rayakar, B. V., Bombay, India.
Sethna, F. M., Bombay, India.

The following candidates were duly elected Fellows of the Society:—

Auckland, George Frederick, London.
Elwell, C. F., London.
Harding, William, Loughborough.
Hodgkinson, Thomas Walter, Purley, Surrey.
Hoyer, Anton Gotfred, Durban, S. Africa.
Joughin, Walter James, London.
Levine, Professor Victor E., Ph.D., Omaha, U.S.A.
Lloyd, William Henry, Twickenham.
McEwen, Alfred, New York City, U.S.A.
Medlicott, Samuel Thomas, London.
Sleigh, Arthur Crofton, London.
Trusler, William Thomas, Enfield.
Williams, Samuel Powell, Bradford.

A paper on "The work of the Royal Botanic Gardens, Kew," was read by DR. ARTHUR WILLIAM HILL, M.A., Sc.D., F.R.S., Director of the Royal Botanic Gardens, Kew.

The paper and discussion will be published in a subsequent number of the *Journal*.

INDIAN SECTION.

FRIDAY, DECEMBER 7th, 1923; THE RT. HON. VISCOUNT PEEL, G.B.E., Secretary of State for India, in the Chair.

The Sir George Birdwood Memorial Lecture, "The Archives of the Honourable East India Company," was delivered by MR. WILLIAM FOSTER, C.I.E., Historiographer, India Office.

The lecture will be published in a subsequent number of the *Journal*.

CANTOR LECTURE.

MONDAY, DECEMBER 10th, 1923; MR. PERCY J. NEATE, M.I.M.E., late Master of the Clothworkers' Company, in the Chair.

Mr. Aldred F. Barker, M.Sc., Professor of Textile Industries, The University, Leeds, delivered the second and final lecture of his course on "Recent Progress in the Wool Industries."

On the motion of the Chairman a vote of thanks was accorded to Professor Barker for his interesting course.

The lectures will be published subsequently in the *Journal*.

MANN JUVENILE LECTURES.

Under the Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 2nd and 9th January, 1924, at 3 p.m., by DR. WILLIAM ARTHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology, on "Fire and Explosions." The lectures will be fully illustrated with experiments.

A lecture will also be given on Wednesday, January 16th, at 3 p.m., by MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, entitled "Among the Selkirk Mountains of Canada (with ice-axe and camera)." The lecture will be fully illustrated with hand-painted lantern slides.

Special tickets are required for these two sets of lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once stating for which lectures the tickets are required.

REPRINTS OF CANTOR AND HOWARD LECTURES.

The Cantor Lectures on "The Vulcanisation of Rubber," by HENRY P. STEVENS, M.A., Ph.D., F.I.C., and the Howard Lectures on "The Development of the Steam Turbine," by STANLEY S. COOK, B.A., M.I.N.A., M.I.M., have been reprinted from the *Journal* and the pamphlets (price 2*s*. each) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures, which have been reprinted and are still on sale, can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, NOVEMBER 27TH, 1923.

LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair.

The CHAIRMAN expressed his pleasure in presiding for his old friend, Viscount Burnham. The Council had hoped that they might be able to have in the Chair one of the Prime Ministers of those Dominions that were interested in the West Indies; for instance, it would have been very fitting if the Prime Minister of Canada, a Dominion which had had much to do with recent developments in the West Indies, had been in this country and had been able to attend. Letters of regret at not being able to be present at the meeting had been received from individuals so interested in the Dominions and Colonies as the Duke of Devonshire, Lord Emmott, Lord Kylsant, Lord Harewood, Lord Inverforth, Mr. W. Ormsby-Gore, and the Master of Elibank. Lord Kylsant added: "I am particularly glad that Lord Burnham is giving this lecture, as I consider it an enormous advantage that a distinguished Englishman like Lord Burnham should personally have visited the West Indian Islands." He (the Chairman) agreed with Lord Kylsant in that statement, and hoped that the personal visit of Lord Burnham was one which many of those present would be able to imitate.

VISCOUNT BURNHAM expressed his pleasure in speaking under the aegis of Lord Askwith, than whom few men were more fitted to deal with matters concerning the British Empire. He (Lord Burnham) would ask them to believe that in talking about the West Indies he was by no means posing as an authority able to speak with fullness of knowledge about them or their affairs; he well knew how dangerous a little knowledge was; he would therefore ask to be permitted to indulge in such remarks upon the present state of the West Indies as were obvious to the least instructed.

The paper read was:—

THE WEST INDIES.

By VISCOUNT BURNHAM, C.H., LL.D., D.Litt., M.A.

The Imperial Conference has come to its appointed or, as the cynic always has it, its disappointed end, and the Prime Ministers of the Overseas Dominions have nearly all bidden us farewell until it meets again. On the whole, it has marked an advance in the organisation of the Empire, even though public opinion in all the Dominions alike shows a definite set against the ideals of federation, which were so popular a generation ago when I was myself a member of the Executive Committee of the Imperial Federation League, of which that great statesman and leader of men, whom we sorely miss, the Earl of Rosebery, was the President. Excepting him, I believe I am the last surviving member of that Committee. Events mock at human foresight and nothing is certain but the unforeseen. In those days we had just emerged from the "calico period" of British history, from the "bagman's paradise," when the Colonies, as they were then called, were regarded as fledgelings fed only by the parent bird until their feathers were grown and then expected to shift for themselves in the full plumage of Parliamentary institutions, after a friendly farewell, such as we bade to the unfortunate people of Heligoland in the early nineties. Even the West Indies were marked out for the same valedictory process. Goods were to be bought in the cheapest market and possessions were to be sold in the dearest market. Every part of the British Empire had its price for the boon of separation or, as it would have been put then, of emancipa

tion from the old country, which was intended to be a free market and clearing house after the model of the Hanse Free Cities in the Middle Ages or the Treaty Ports of China in our own time. The Colonial Office of the Victorian epoch up to its culminating Jubilee, which strangely upset the official mind by its inspiring call to Imperial patriotism, had a nicely adjusted plan of operations for dealing with the British West Indies. The first step was to forge a federal union under a Parliamentary constitution, which was then supposed to be a cure-all for human ills, in which without racial distinction or local differences all good citizens would combine for the common good. The constitutional arrangements of the various islands were to be assimilated or, shall I say, ignored, and the result was to be a union of hearts and minds, such as Mr. Gladstone predicted in John Bull's other island. It was not quite clear how the transformation scene would be staged, because of the ugly memories of racial riots and disorders, the embers of which were yet smouldering. Consequences are unpitying and the terrible incidents of the Slave Trade, such as Mary Gaunt has painted in her last book, were still a tradition if not a memory among the coloured people of the Caribbean. Then there was the unfortunate example of Haiti, where the French theories of liberty, equality and fraternity had somehow missed fire and been supplanted by the primitive and regrettable methods of barbarism and a massacre of the white colonists. Still, nothing damped the humanitarian enthusiasm of the old Colonial Office. "Try liberty" was the watchword or what is called in current political slang "the slogan" of middle class humanitarianism, and the West Indies were believed to be not only ready, but anxious to be liberated from the yoke of a stony-hearted mother country. Unfortunately for these well-intentioned articles of the official creed, the British West Indies did not want the panoply of full Parliamentary constitutionalism, and they were not sufficiently prepared for human brotherhood to dispense altogether with fancy franchises and political preferences. They thought that the mother country still owed a duty and obligation to the old and loyal colonies, which had never failed her for two centuries of chronic warfare and mutual trade relations. With all the multitudinous difficulties of race and colour, these colonies still required the guiding hand and the protecting shield of England and they wanted none other. The words of the Latin motto of the town of Kingston, the capital of Jamaica, "Hos fovet et curat servatque Britannia mater," were taken to embody a ruling principle in the government of the British Empire, and the West Indies wished—and I say with sincerity still wish—that they be enshrined in perpetuity under the Empire coat of arms. The grant of self-government was to have led up to either of two alternatives—a federal republic of the islands *inter se* or annexation to the United States of America, which was regarded as what was called the manifest destiny of an overburdened and bank-balanced nation of shopkeepers. Many things have happened since then, and the irony of fate has turned to folly the wisdom of the wise. Curiously enough, however, the latter alternative has cropped up again in the last two years. For a long time after the Civil War, the United States had renounced that form of spread-eagleism, which aimed at increase of territory within the Union with its disturbing effect on party politics, especially as in the first instance these additions to the South obviously threatened the domination of the Republican Party, which had followed the "carpet-bag" régime in the Southern States. California, Texas, and New Mexico took quite a lot of digesting even after the Civil War. Recently, however, the taste for Imperialism has again taken hold of the American people and has been much stimulated by the opening of the Panama Canal and the necessities of the Prohibition Party. This year Senator Reid, of Missouri, raised the question of the British West Indies in the Senate. He said they threatened the mouths of the Mississippi and the entrance to the Canal and moved that negotiations should be opened for their transfer to the United States in part payment of the War debt of Great Britain. Mr. McAdoo, the son-in-law of President Woodrow Wilson, first started this little game and with his tongue in his cheek averred that such a moral surrender would be to the advantage of both nations. It is only fair to say that the United States Government gave no support to the proposal, but it is supported all the same by a

considerable part of the newspaper press, including the *Chicago Tribune,* which is the most important journal of the Middle West. Even more serious is the use being made of the claim by the Prohibitionist Party in the course of their internecine struggle with the "bootlegging" industry, for this may in time make it a plank in the party platforms with all the political mischief that may ensue. The Chief Justice of the Bahamas had reason to speak out about the slanders directed against the colony quite recently. A London daily newspaper had actually acquiesced in the monstrous demand that the Bahamas should be handed over to the United States on the ground that it had become a centre of "American crooks and gunmen." The Chief Justice said: "It cannot be too widely known that in no part of the British Empire is there greater security of life and person and property." From what I saw in my short visit this spring, I can heartily endorse this pronouncement, but the need for making it shows how insidiously the machinery of propaganda is at work. The other reasons for the annexation movement are commercial and financial, and there is no doubt that the peaceful penetration of American trading acting with the passive assistance of British apathy has had a great effect upon the social economy of the West Indies.

In Tom Cringle's Log there is a vivid description of the entrance of the *Firebrand,* one of the ships of King George's Navy, into the port of Santiago de Cuba, in the course of which he speaks of the "sleepy folds" of "the golden flag of Spain," but qualifies it by saying: "The Spaniards in their better days were a kind of coral worm; wherever they planted their colonies they immediately set to covering themselves in with stone and mortar." For a long time past the British Government has not been even a "kind of coral worm" in the West Indies. Even in those days Tom Cringle talked of the "political fermentation" caused by the United States "in those countries," but the fermentation is much more commercial than it is political to-day, and it is only fair to say that but for the business enterprise and organising "lay-out" of the United States the British West Indies might well be on the financial rocks of bankruptcy to-day. The West Indian Colonies have been called "Islands of Samples," on account of the multiplicity of their products and the small scale upon which each has been developed: but America resolved to turn the samples into big business and has, on the whole, been very successful. Sir Charles Lucas prophesied that the twentieth century would witness the regeneration of the West Indies as the nineteenth century had been their time of decadence and decay, mostly, as we all know, on account of the callous and selfish policy prompted by short views and economic fallacies pursued by Great Britain at the behest of the Cobden Club. You will all recollect how sternly the elder Pitt in the majesty of his greatness rebuked the Member of Parliament who laughed when in the course of a great speech he uttered the word "sugar," but laughter such as this has nothing but bitterness in it for those who can laugh at the folly and the perversity of the sugar policy of Great Britain in the last century, which enriched and fortified her enemies and confounded and brought nigh to ruin her own plantations and provinces. The Great War caused unexpected revival in the sugar industry of the West Indies. Mortgages were paid off and sugar mills equipped with modern machinery. Even if prices have fallen and fluctuated since, as was only to be expected, the state of the sugar trade within the British Empire is much better and sounder than it has been for fifty years, and the announcement made by the President of the Board of Trade at the Economic Conference will give it an assurance and stability which it has woefully lacked in the past half century. Under the Reciprocal Trade Agreement of last year, Canada gives Canadian products a preference of 50 per cent. at most with a sliding scale downwards, and it is certain that, as the population of the Dominion grows and her vast territories are brought under settlement, their consumption of West Indian exports will increase proportionately, for Canada has no tropical or sub-tropical lands within her borders. The United States, none the less, is still a good customer, although she has lost some of her import trade into the British West Indies, which, according to the Trade Commissioner's last report, showed a falling off last year of 40 per cent. as compared with 1921 against only 24 per cent. in the case of Great Britain and an actual increase in the case of Canada. Canada, indeed, has not only captured some of the American

trade, but has also obtained important contracts for railway extensions and dredging works. What the United States have done is very effectively to promote the production of sugar on a large scale in Cuba, where there are mills turning out 100,000 tons and more in the year, and to give a secure preference in their mighty markets to the output of American interests in tropical industries. I use the word "interests" advisedly because I know that Cuba is a Sovereign State and does not accept, even in theory, any suzerainty in derogation of her independence, but in practice the United States treats Cuba as being almost a puppet within her sphere of influence and exploits her resources with vast momentum. Only this year the United States Treasury advanced forty million dollars in aid of Cuba's financial budget and appointed an Ambassador there, who appears to be more of a Comptroller than a diplomatic representative, and in Cuba American business houses have embarked in huge and productive enterprises on the big scale. Havana itself is being laid out and developed by American capital into a Southern city of splendid surroundings on the finest lines of American town planning. All this points the moral of a comparison between the starvation policy that Great Britain has pursued in her colonies, and the characteristic courage of American business, which is statesmanship marked "private enterprise." The British West Indies need, so they tell us, a combination of British initiation and British resources to undertake their restoration to the prosperity of other days, but, when a West Indian merchant or planter makes a proposal involving the assistance of British capital, he is met, as I had reason to note the other day, by our banking houses with the reply, "Why try to make a British company when you can get the money so much more easily in New York?" That is partly the explanation why the trade in bananas, which has been the salvation of Jamaica, has passed almost exclusively into the domain of American enterprise. The United Fruit Company is a standing credit to the foresight and fortitude of American business, and at this very moment, according to our Trade Commission, an important American Company, almost certainly in alliance with it, is surveying British Honduras, which was at one time a large producing area, with a view to re-establishing the industry there on a big scale. For Jamaica the United Fruit Company has meant the difference between plenty and penury. They go along taking up and developing as much of the land as a somewhat shortsighted policy enforced by penal taxation on estates over a certain size will allow them to do. Everywhere their plantations are well and scientifically cultivated and they have spent large sums of money in fighting against the Panama disease, from which the banana industry has suffered such serious losses. Moreover, wherever they have set their foot, they have seen to it that their labouring workmen are housed in a decent and sanitary fashion, which shows up unpleasantly by way of contrast the noisome and ramshackle hovels in which most of the peasantry live. In flattering testimony to the value of British service and American recognition, it may be mentioned that out of a white staff of some fifteen hundred employees of the Company only four, as I was told, were American citizens. The overseers of black labour are all Englishmen. This shows a delicacy of feeling and an impartiality of selection, such as we have not always been prepared to allow to the conduct of American corporations. There is no mistake about it, all the same, that the banana industry is something very like an American monopoly, look at it as we may, but it admirably illustrates both the strength and the virtues of Americanism in business. The exportation and marketing of bananas is almost exclusively in American hands, and it is a curious fact that nearly the whole crop that is harvested in Jamaica goes to Boston, whence about a sixth finds its way to Canada, whereas the English market is supplied almost entirely from the mainland. This is in no sense a political operation, but is dictated by the economic expediencies of the trade, which lay down the trade routes according to the best drawn scheme of operations in the market places of the world. Meanwhile, one hears not a thin, small voice, but a long-drawn wail, which must appeal to British ears, that whilst there are many independent planters who raise bananas of an excellent quality on their "pens," they cannot get them to the European markets, because the regular line of communications is controlled by the United Fruit Company and they carry no bananas

but their own, in which case their cry is veritably "We take no bananas to-day" or any day. That seems a strong argument in favour of a subsidised service between the mother country and the West Indian Colonies, such as existed for forty or fifty years, both for passengers and goods. Lord Kylsant told me that the Royal Mail Steamship Company lost a million on it during the currency of their contract, and it will not be easy to obtain its renewal on adequate terms, but, meanwhile, the connecting lines have been largely cut, and, after holding the Caribbean Sea within the folds of the Red Ensign for two hundred years and more, we are now dependent to a large extent on tramps and tourist pleasure boats. Nor is it any real compensation that the fleets of ships which are employed in the new industry of boot-legging and rum running, which, I understand, to be among the strongest supports of prohibition in the United States, sail under the British flag. This question of sea communications is literally and truly a constant source of irritation and complaint, because, apart from the regular service once a fortnight from England to Jamaica, all communication between the islands has come to depend on the services of tramp steamers with the occasional call of great tourist boats which hail from the United States, even though sailing under the British flag. It was given me as an amusing instance of the attitude of the official mind in England that, when the extra battalions of the West Indian Regiment —which earned much credit and praise during the war—were about to be disbanded and sent by detachments to their home stations, the War Office issued an order that they were to be forwarded so far as possible by train. This gives rise to the laughter with a salt of bitterness that is akin to tears.

It should be borne in mind, too, that American influence in the West Indies is not limited merely to commercial transactions. It is due also to the travel habit of the American people. It has been said that you should form habits in youth in order to shed them in later years, but the mobility of the American citizen is a great national asset, that lasts as long as life itself. It is very difficult in these days of chance and change to run counter to the conveniences of life, and in exchange of goods and persons geography is on the side of the United States. We cannot, however, rest and be thankful in our present stage of colonial relations—at least we cannot rest and the Colonies have not much to be thankful for. The West Indies will not and cannot run themselves; they are formed *ex natura rerum* to be largely dependent, and, although they have all the bounty of the tropics in riotous prodigality, they have all their disabilities and ineptitudes. They cannot stand alone, and assuredly they cannot advance entirely unaided. The West Indies live under the charm of the lotus tree, but they suffer from its enervation and this makes them to some extent dependent on our help and guidance. Cut off to so large an extent from the big movements of men and things, they tend to develop an insularity comparable only to the number of their isles and islets. It struck me that the division of Jamaica into nineteen parishes had infected the colonists with a certain parochialism of outlook, which sometimes stands in the way of the co-operative commonwealth that the British Empire has to be, if it is to continue as a secure and stable reality in a world of illusions. It could not well be otherwise, and it is for us to supply the corrective and the stimulant from the power-house of British vitality by the broadcasting of British ideas and Imperial patriotism.

I am no stickler for forms of government and in the case of the British West Indies there is a great deal of wisdom in Pope's line, "That which is best administered is best," but there is no doubt that too little care and discrimination have been exercised by the Colonial Office in the selection of Governors and high officials for the various colonies. It is more or less true that half the evils of the world arise from putting three-cornered men into square holes and square men into three-cornered holes, and it is a case of mistaken ingenuity to prove that the fear of failure is not always justified. The classic case of Daniel Parke is an early example of what it means to test in this way the loyalty of the Colonies. In the "History of Colonel Parke's Administration whilst he was Captain General and Chief Governor of the Leeward Islands" by Mr. George French, printed and sold in London in 1717, it is narrated that "His Grace the Duke of Marlborough having sent Colonel Parke (his aide-de-camp) express to the late Queen with the first account of the glorious victory

obtained at the Battle of Horstet, Her Majesty received the welcome news with great transports of joy and was graciously pleased as 'the messenger of such happy tidings to the nation deserved' to appoint him Captain General and Commander-in-Chief," of the Leeward Islands. He was no doubt a fine figure of a man, but he had been expelled from the House of Commons for bribery and had only escaped prosecution by the favour of a courtier; he had seduced the wife of an officer in the Guards, and he was, in general, a thorough-paced ruffian. His advocate says that "so far as was possible for a Lord Chancellor or Chief Governor in all causes to please each party, he had entirely gained the hearts of the people,' but because he was 'too honest' according to his friends, 'a set of men actuated by malice, envy, self-interest or such like devilish principles, imbrued their hands in his blood' with 'circumstances of cruelty and barbarity." In 1710 he was brutally murdered by a riotous mob headed by the 'Assembly men". . . "accounted the representatives of the people." There may be some doubt as to whether the measures that he meant to take against the French vessels were reasonable or not but he was an arbitrary and unpopular man, and he perished not so much for what he did as for what he was. As you scan the long list of West Indian Governors, you encounter at every turn the names of the proudest families of the British and Irish peerage, but the selection of their heads and members must have been on a par with the nepotism and corruption of the Whig oligarchy like so much else in the politics of the past. Of that in any form there is not much trace left now, but it may well be that our invariable course of official promotion in the colonial service, tempered still by occasional acts of political jobbery, does not always give the Colonies the best men available, I say nothing of the ideal men, who are mostly unavailable. There is a saying that in Jamaica the people receive everybody well except their Governors, and I am far from saying that it is easy to avoid criticism or even censure, if not as in Governor Parke's case by "Articles of Impeachment clandestinely forged" or even "Petitions of grievances, those lights of discontent and dark lanterns of rebellion," at least in newspaper articles and platform speeches. You will never satisfy everybody, but disappointments might be more easily avoided if appointments were subject to confirmation by a Cabinet Committee and if, as is now the case in a conferment of titles of honour by the Crown, a reasoned record and recommendation of every person to be entrusted with such office were published *urbi et orbi*. In the same way, I hold that the representative principle should be applied to the larger group of colonies, instead of always trusting to what Bismarck called "the spirit of the green table," for the pure—and it is pure—officialism of Downing Street is undoubtedly out of date. The jest applied without much reason to the great financial house of Baring—bearing, overbearing, and past bearing—represents more or less what the colonies feel about Whitehall, yet nobody speaking with knowledge can say that the time has yet come or will come for many a long day when Great Britain can scrap her colonial service or when her colonies would be better off if she did.

History never repeats itself except by analogy and to me, as an old Parliament man, the Parliamentary history of the West Indies, with all its moving pageant and all its tragic failures, is a warning written in letters of blood and tears against the facile and ignorant optimism which puts faith in tinsel imitations of our Parliamentary institutions in countries that are petrified by religious castes or a prey to savage feuds and hatreds. The Barbados and the Bahamas have a Parliamentary tradition carrying us back to 1625 and 1647 respectively and Jamaica only surrendered its Parliamentary privileges in 1866 to those whom Carlyle spoke of in "Niagara and After" as "a group or knot of rabid Nigger Philanthropists barking furiously in the gutter." It could not, however, have amounted to much in its latter days. Anthony Trollope has left us a description of a Parliamentary sitting which he attended, where the only Parliamentary bar was a drinking bar, which the members attended and where ribald talk went on without let or hindrance. Parliamentary representation of the West Indian families, like the Beckfords and the Gladstones, when such men as "Monk Lewis" had seats in the House of Commons and West Indian questions were discussed there with knowledge and sympathy has departed for good or ill. The old planter families have died or been bought out, although the "great houses" of Jamaica still bear witness to

their opulence when, as Mr. Aspinall puts it, "sugar was king." Representation of that kind has gone beyond recall. On the other hand, just as the Federation of British Industries or the Miners' Federation have their nominees in the House of Commons, so by reviving the wholesome and historic principle of virtual representation, the Associated Chambers of Commerce of the British West Indies and the West India Committee ought to have representative members in Parliament. I can only hope that some of them are among the candidates at the forthcoming General Election.

Then, I again put forward a plea for the constitution of the office of High Commissioner for the British West Indies to take his place in the official world immediately after the High Commissioners for the self-governing Dominions and before, say, the Agent General for the Malay States. In the eighteenth century all the important colonies had their agents at the seat of Empire to transact their business and advocate their claims, for it must never be forgotten that the West Indian islands loomed much larger in the eyes of Old England than they do to-day. Byron's words applied to them in full:

"I longed to see the isles that gem
"Old Ocean's purple diadem.
"I sought by turns and saw them all."

Few English people seek to see them to-day, and, did they seek, they would find the travelling facilities quite insufficient. It is said that the want of confederation or even of co-operation among the West Indian islands makes any joint agreement for the appointment, still more for the payment, of such a high officer of state unlikely, if not impossible. It may be so, but federation will not come into being unless it hangs on a political issue and seems to promise a general advancement all along the line.

Constitutional agreements which are conceived by philosophers and made in the senate seldom fulfil the hopes of their authors. Mr. Gladstone spoke of the constitution of the United States as the greatest achievement of human wisdom that ever came full-fledged from the mind of man, but this is, like so many of the old fallacies of constitutional government, quite a mistaken view. Mr. Beck, the Solicitor-General of the United States, has recently explained in a course of lectures before the Inns of Court in London that the constitution of the United States was made up of a series of borrowings and extracts from the varying constitutions of the different colonies, who first came together in a federated state for the purposes of defence. In fact, in a sense, the constitution of the United States is one big "appropriation clause" from the British Constitution, as broken up in the 17th and 18th centuries among the plantations of America.

To make a constitutional consolidation of West Indian interests will be no easy task, but to begin by having a High Commissioner who can embody the proud traditions of these old colonies would be characteristically British and eminently business-like. He would be at once a political envoy and a commercial agent, and that is not a bad combination in these days, when for want of trade the nations perish. Who represents the West Indies at this moment in the Colonial Office or in the City is wrapt in mystery, but probably you might discover him after a walk down endless corridors in one of the labyrinths of Whitehall and the labyrinth of the office is, to vary Tennyson, the labyrinth of the official mind. When I was young in Parliament, more than thirty years ago, I was appointed to the Royal Commission on Civil Establishments of which Lord Lingen was a member. You may never have heard of Lord Lingen, but for a generation he had been head of our Civil Service as Permanent Secretary to the Treasury, and Lord Beaconsfield had said of him, "the real Governor of England is Mr. Lingen." He was almost unknown to fame, and he hardly figures even in the history of our own times. If you wished to find the Governor-General of the West Indies, you might have to pace the passages of the Colonial Office until you came to a small room indifferently lighted and there you would find in the person of an excellent head of a department the power behind the throne. Who he may be at the moment I do not know, but I am certain that he is a public servant of the highest character. The Tite Barnacles of Dickens's novels were all good men, in their way, but the civil servant of our day is something much better—and you may rely upon it that he is a patriot and a gentleman. Yet, for all that, I do not believe that the Colonial Empire, excluding the self-governing Dominions, can any longer be run on the labyrinthine principle. Hole and corner administration is no longer

sufficient for its purposes, and the grotesque mistakes that are sometimes made in the appointment of Governors and Lieutentant-Governors to the Crown Colonies are all due to the labyrinth of the official mind and not to any practical joke department of the State. The British Empire may not be altogether a garden city, for it has its mean streets and its slum areas, but it is assuredly a city of many gardens, "from Greenland's icy mountains to India's coral strand," and its gardens require affectionate understanding and sympathetic tending. "We must cultivate our garden," as Candide tells us, or it will pass to other hands.

The Imperial Conference which has just, to use the official phrase, concluded its deliberations, did something to remove the reproach that in the competition and clash of imperial interests the West Indies were always forgotten. The Under Secretary of State for the Colonies was advised by a Committee on which Sir Edward Davson, an excellent nominee, spoke for the West Indies. It was a step in the right direction, but I hope that at the next Imperial Conference the West Indies will have separate and individual procuration. At the Economic Conference, which was rather a different incarnation of the main Conference than another body, the stabilisation of the existing preference of one-sixth or 4s. 3½d. per cwt., being nearly a half-penny a pound on refined sugar grown within the Empire was recommended for a period of ten years, and the extension of the fruit clauses, although not intended especially for the benefit of the West Indies may have a beneficial effect on their agricultural production. I quote the report of the conclusions arrived at: "It is not possible at present to offer an increase in this preference, but His Majesty's Government are ready to guarantee that if the duty is reduced the preference shall for a period of ten years not fall with it, but be maintained at its present rate of nearly ½d. per pound so long at least as the duty on foreign sugar does not fall below that level. At present dried fruit, figs, raisins, and plums (including apricots), are dutiable at the rate of 10s. 6d. per cwt., if from foreign countries, and enjoy if of Empire origin a preference of one-sixth, i.e., of 1s. 9d. per cwt. It is proposed to admit these goods free of duty from the Empire so that Empire raisins, figs and plums will enjoy a preference of 10s. 6d. per cwt." Unfortunately, owing to the exigencies of party warfare, on the principle of the in and out system or the battles of the kites and crows, a preferential tariff, which includes sugar, has become a plank in the party platform to be alternately attacked and defended, by walking the plank or otherwise. The Cobden Club is clearing its trenches of the debris and the dust heaps of the old struggle of a hundred years and is once more using, as the French had to do in the Great War for want of heavy artillery, the mortars that did duty in the Crimean War. I cannot help expressing my regret that the old cry "What is the Empire to Battersea?" should again echo through the land.

In respect to communication by sea and air, under the sea and above the air, the decisions of the Imperial Conference do not carry us much further. The conditions of transport to the West Indian islands are regrettable in the extreme, and they cannot be set right unless the Imperial Exchequer is prepared to give more liberal terms to British shipping. It will remain nothing short of a scandal that the freight ships of the banana trade should be in the hands of an American Corporation, however enterprising, and that except for tramp steamers it is virtually impossible to travel at all or with reasonable speed and regularity in any case between one colony and another. So far as British shipping goes, the sea routes of the Empire in the West, where our flag was supposed to proclaim our home, are derelict and forsaken.

In regard to telegraphic cables, some progress was reported, of which the particulars have several times been stated, but the rates still present a picture of strange and capricious variation. To the Bahamas via Florida, the press rate from this side is 1/1½d. a word, whereas to Jamaica via New York-Havana it is only 8½d. To British Guiana via Colon it is 3/3½d., but via Key West it is 1/0½d. All these differences are very picturesque but the result is, in regard to such a colony as British Honduras, that all the news service is forced on to the American wires or wireless.

When we turn to the latter branch of intercommunication there is nothing to report. In the part of the world where wireless telegraphy is most wanted, we continue to accept the ridiculous plea that the atmospherics are unsuitable, although Senator Marconi tells us that is a difficulty that exists only to be surmounted.

It is profoundly true in such matters that where there's a will, there's a wire, and it is the will to power, not the skill to power, that is still wanting and to seek.

Aviation has had some share of the attention of the Economic Conference, and it is to be hoped that it will no longer be the case that the only flying service over the Caribbean is that between Miami on the coast of Florida and the Bahamas, which has been carried on regularly for some three or four years. If there was an archipelago which lent itself to an air service it is surely the West Indies. The air ship routes contemplated by Commander Burney may not touch on Central America, but it is well worth the Secretary of State for Air taking into consideration the fine opportunities that are offered in this sphere of British influence. The West Indies suffer from a certain lethargy, which does not amount to slackness, if left by themselves. It was well expressed in a sentence of a complaint from the island of Nevis so far back as in the days of good Queen Anne:—"The people of Nevis expect the Queen should do everything for them, though they do not endeavour to help themselves." Climate and environment always have their effect on national character and conduct, as Buckle explained in so large a way in his "History of Civili ation" seventy years ago. So mote it be, the archaic formula has it.

I cannot finish this subject better than by a quotation from J. A. Froude, who had an easy command of glowing language which is beyond my capacity: "At one time the West Indian Colonies had been more to us than such casual seedlings. They had been regarded as precious jewels, which hundreds of thousands of English lives had been sacrificed to tear from France and Spain. The Caribbean Sea was the cradle of the Naval Empire of Great Britain. There Drake and Hawkins intercepted the golden stream which flowed from Panama into the exchequer at Madrid, and furnished Philip with the means to carry on his war with the Reformation. The Pope had claimed to be the lord of the New World as well as of the Old, and had declared that the Spaniards, and only Spaniards, should own territory or carry on trade there within the tropics. The seamen of England took up the challenge and replied with cannon shot. It was not the Crown, it was not the Government, which fought that battle, it was the people of England, who fought it with their own hands and their own resources. Adventurers, buccaneers, corsairs, privateers, call them by what name you will, stand as extraordinary but characteristic figures on the stage of history, disowned or acknowledged by their sovereign as suited diplomatic convenience. The outlawed pirate of one year was promoted the next to be a governor and his country's representative. In those waters the men were formed and trained who drove the Armada through the Channel into wreck and ruin. In these waters, in the centuries that followed, France and England fought for the ocean empire, and England won it—won it on the day when her own politicians' hearts had failed them, and all the powers of the world had combined to humiliate her, and Rodney shattered the French fleet, saved Gibraltar, and avenged York Town. If ever the naval exploits of this country are done into an epic poem—and since the Iliad there has been no subject better fitted for such treatment or better deserving it—the West Indies will be the scene of the most brilliant cantos. For England to allow them to drift away from her because they have no immediate marketable value, would be a sign that she had lost the feelings with which great nations always treasure the heroic traditions of their fathers. When these traditions come to be regarded as something which concerns them no longer, their greatness is already on the wane."

DISCUSSION.

The CHAIRMAN (Lord Askwith) thanked Lord Burnham for the admirable paper which he had read. Referring to the allusion to the peaceful penetration of the United States with the passive assistance of British apathy, he felt that in our dealings with our Dominions and our Colonies we had come to a new era when by co-operation and working together there might again come a time when islands such as the West Indies would be looked upon as the jewels of our Empire. Lord Burnham had touched on much: there was much that he had had to leave out. He had not even alluded to Jamaica rum, an important thing in the last war and in many other wars before. He had not spoken of the woods of the islands, nor of, the asphalte and other oil products, which as a trade were thriving in Trinidad, an island more connected with the mainland than the other islands, but included among the West Indian islands. The rest of the islands were geologically supposed to be the tops of mountains, which originally were connected with Florida by land. Including Cuba, their extent was about 100,000 square miles, as compared with an area of

12,000 square miles of the British Isles. By that comparison one could appreciate the large extent of territory comprised. That territory possessed many kinds of products, although they were "samples," amongst which it might be unwise to mention snakes, adders and insects. There was much to be seen by tourists who could travel from island to island. Captain Marryat, in his splendid novels, had, with that power of description which he possessed, described in a marvellous way the scenery of Barbados and other islands.

SIR EDWARD DAVSON offered his congratulations to Lord Burnham on the very graphic and eloquent paper which he had read. He also congratulated the West Indies on having been able to enlist the sympathy and interest of Lord Burnham, who was one of the busiest men in the Empire, a great patriot, and one whose name stood for all that was best in journalism. It was indeed a very happy circumstance for the West Indies that he had been induced to spend a few months last year in those parts, and it was to be hoped that at some time in the near future he would be able to complete his tour of the islands. Meanwhile, he had already left his mark in the West Indies by the formation of a West Indian Branch of the Empire Press Union. If that organisation could lead to any improvement in the press news of the West Indies, it would have done a great work in helping that part of the Empire to understand what was going on at home better than they had done in the recent past. An enterprising editor in the Island of Trinidad had put up a wireless station of his own from which he was able to obtain news which was sent out to the World, and was thus relieved from the necessity of being dependent on news which usually emanated from American sources. The Colonial representation which had been obtained at the Economic Conference was in a large measure due to the work of Lord Burnham, who, in an eloquent speech in the House of Lords, had put forward the need for Colonial representation very forcibly. The Resolutions of the Economic Conference, if confirmed, would prove of very great benefit to the West Indies, that with regard to the stabilised price of sugar being most important. The West Indies and British Guiana were most anxious to show what they could do in the way of sugar production. This country consumed 1,800,000 tons of sugar a year, and British Guiana claimed that given favourable conditions it could produce at least half that amount. There were other Resolutions affecting the welfare of the West Indies, and it was unfortunate from the West Indian point of view that these matters had become the subject of party strife in politics. He was not going to touch on present day politics, because he did not think that was wanted at that meeting, but he hoped, whatever might be the outcome of the forthcoming General Election, that the Resolutions passed at the Economic Conference would be confirmed. It had been intended to send to the West Indies a party of Members of Parliament; unfortunately at the present moment the members of this proposed party were no longer Members of Parliament, and did not know whether they would be re-elected. It was to be hoped that if the party had to be postponed, it would merely mean a postponement and not an abandonment. He did not see why the West Indies should not have a High Commissioner. The title "High Commissioner" was in fact used exclusively with reference to the Dominions and India, but whatever title was best could be used, that being unimportant. One difficulty was that of getting a definite opinion from the West Indies on the subject. He thought Jamaica approved of the idea, Barbados did not altogether approve; Trinidad considered that another scheme might be adopted by which the West India Committee could do the necessary work; British Guiana desired to have a Trade Commissioner, or whatever he might be called, entirely to itself. It was obvious, therefore, that before such an appointment could be made there was a good deal of work to be done in bringing together opinion in the West Indies. He was also rather afraid that if, and when, the gentleman was appointed there might be some difficulty as to who was to control him. He might have about six masters, and when one had six masters, one had not any master at all, while possibly there might be a good deal of jealousy if he advocated the claims of one Colony in preference to those of another. But he was sure Lord Burnham would say these were difficulties which only existed in order to be overcome, and he hoped the attention of the West Indies would be given to these very important matters.

MR. R. RUTHERFORD (Chairman of the West India Committee) expressed the thanks of all interested in the West Indies for the very interesting paper which had been read. He hoped Lord Burnham would repeat his visit to the West Indies.

MR. H. MEDLICOTT RUMBALL said he intended to visit the West Indies. He did not think anybody could have read the papers during the last few years without recognising what a great debt of gratitude was due to Lord Burnham, who had the interests of the Empire so much at heart. Looking back at the condition of London when he was a young man, and considering the changes which had since taken place, he asked himself: Whither are we tending? It was men like Lord Burnham who could lead and advise. The West Indies had glorious traditions; their history was the story of great achievements, and he asked why the same things were not taking place to-day. Surely Englishmen had the same amount of enterprise as Americans. Means of communication were the basis upon which development in the West Indies must proceed. Surely the trade of this country could support a line of British steamers to the West Indies. The mother country must give a little help to tropical products, which we did not, of course, produce ourselves. We badly needed

sugar, which was at a high price. Why should we not help the Colonies to produce that sugar?

Viscount BURNHAM thanked those who had spoken for the kind things they had said; they had attributed to him more than he could lay claim to. In the House of Lords he had been glad to break the silence as to the West Indies which had existed, he thought, for nearly 25 years. Certainly in both Houses of Parliament the West Indies had not received the attention which they deserved, and that was especially a matter for comment in the House of Lords, where there were great opportunities for raising questions. As Chairman of the Executive Committee of the Empire Parliamentary Association, whose membership included nearly all the Members of Parliament in the Empire, he had thought it of the utmost importance to urge upon his colleagues the desirability of sending out a party of Members of Parliament to the West Indies, though he could not claim to be the originator of the idea, which had been warmly taken up, and, as far as he knew, had not been abandoned. It had been intended that a delegation of Members of Parliament and their ladies consisting of 40 persons should go out. He had seen many of the members of that delegation, and they had been anxious that their going should not depend on re-election to Parliament, and he had felt that if there were a substantial number re-elected—at least three quarters—perhaps the West Indies would not feel aggrieved that there were a small minority who had not secured re-election and would accept their nomination as from the last Parliament. Such a personal tour would be of great benefit, and as a consequence a great deal more would be heard in the House of Commons about the Caribbean than had been said during the last 30 years.

DR. J. A. VOELCKER in seconding a vote of thanks to Lord Burnham, proposed by the Chairman, said the paper had been one full of life and fire, and, coming from such an authority, would carry great weight and draw more attention to the needs of our Colonies, and the West Indies in particular. He personally had never been to the West Indies, though he had had to do with those Islands, chiefly in regard to agriculture. He had heard a great deal of the labours of scientists who had gone out to the West Indies and worked under great difficulties. Greater attention was now being given to agriculture than formerly. Not long since the Colonial Office had moved with a view to the establishment of a college in the West Indies, and a recent Member of the Council of the Society, Professor J. B. Farmer, of the Imperial College of Science and Technology, had made a tour of the islands in order to see what the state of the different agricultural industries was. As an outcome of that mission a number of appointments of botanists, chemists, entomologists, &c., had been made, and there was hope that in the future, whatever had been the position in the past, more attention would be given to the needs of agricultural industries in those parts. It was not a matter which concerned merely the West Indies. In England a large number of scientists were being trained in the Imperial College of Science and elsewhere; very few of those students would be able to get appointments in this country, and there arose the problem as to how their energies were to be utilised. There was a promising outlook in the West Indies and similar places where there were many questions unsolved with regard to plant physiology, the diseases of plants, the attacks of insects, which in many cases threatened ruin, and the removal of which would be of great advantage.

The motion was carried unanimously and the meeting then ended.

MR. ALGERNON ASPINALL, C.M.G., writes:—

Owing to the receipt of several urgent cablegrams from the West Indies which required immediate attention, I was at the last minute prevented from attending the meeting of your Society on November 27th, and of listening to Lord Burnham's Paper, which I have read with much interest.

All connected with the West Indies should be grateful to Lord Burnham for the close and practical interest which he has taken in West Indian affairs since his visit to Jamaica; and perusal of his Paper shows clearly that he has dipped deeply into the romantic history and literature of our oldest group of Colonies.

One has heard of the disastrous attempts to federate the scattered islands in the group, which culminated in disturbances in Barbados in the seventies of last century, but I confess that I was quite unaware that this was to be a preliminary step towards the alternative of a federal republic or annexation to the United States of America, a policy which I am glad to note that Lord Burnham denounced in no measured terms. It is monstrous that any Englishmen and English newspapers should suggest the transfer of our Colonies in the Caribbean Sea, which have aptly been termed the "Cradle of the Royal Navy," to a foreign flag!

Lord Burnham in his Paper referred to lack of British enterprise and initiative in the West Indies. In this connexion it must not be forgotten that though Americans have "put it over" us by developing the banana industry in Jamaica (which they have done with such remarkable efficiency), British capital has been forthcoming recently for development of the diamond industry in British Guiana, for the acquisition and maintenance of Gray's Inn Sugar Estate in Jamaica, and for the development of the petroleum industry in Trinidad (in which at least £6,000,000 is invested) and that at the present moment negotiations are proceeding for the establishment with British capital of a Jamaica Sugar Syndicate under the auspices of the Duke of Atholl and Lord Invernairn, for developing large areas in the South Eastern part of Jamaica under sugar and other forms of

cultivation. Moreover, quite lately a loan of £1,000,000 was successfully floated in this country for British Guiana.

I mention these few examples to show that British capital is available for the West Indies where substantial and businesslike propositions are concerned.

The suggestion that a High Commissioner should be appointed for the West Indies is an interesting one; but I fear that Lord Burnham has hardly appreciated the difficulties which exist in harmonising the divergent views and interests of the scattered group of islands before an official can represent the United West Indies. Meanwhile the offer of the West India Committee to conduct a trade commissioner service for the colonies concerned for a nominal annual payment remains open, and with the closing of the Exhibition Galleries at the Imperial Institute imminent, the question of housing the West Indian economic collections there will have to be considered.

Lord Burnham correctly diagnosed the situation generally when he attributed the present insularity of many of the units forming the British West Indies, to lack of communications. Mr. Edward Wood, after visiting the Colonies last year, stated that federation of the West Indies must be "a plant of slow and tender growth." With that statement I entirely agree, and would add that the best fertiliser for the plant would be improved and cheaper inter-insular communication by means of steamships, cables and wireless, and one cannot help feeling that it would pay in the long run if an official could be appointed of the calibre of a Milner or a Cromer, who could constantly tour the islands themselves and preach the advantages of unity and combination.

In conclusion, I should like to express my indebtedness to Lord Burnham for the assistance which he has recently been affording to the British West Indies in many ways, and notably in the direction of securing publicity for their many attractions and the ventilation of their numerous problems.

MR. R. RUTHERFORD writes:—

If I had known that I was to be called upon to speak on the occasion of the meeting on November 27th, I would certainly have said a little more than I did.

I would have liked, for example, to say something about the Imperial College of Tropical Agriculture, which promises, I think, to be one of the most important pieces of constructive work to be carried out by the British West Indies for many years. With headquarters at Trinidad, it will cater for the Empire as a whole in the direction of providing facilities for education in Tropical Agriculture and allied sciences, and what to my mind is, if anything, even more important, practical research.

The College is now recognised as a training centre by the Empire Cotton Growing Corporation, which has sent several students to it, and I hope that Lord Burnham may be induced some day to pay a visit and inspect its well-equipped laboratories.

As Chairman of the West India Committee, I would like to have said something also about the proposed Parliamentary Delegation to the West Indies, the arrangements for which are being carried out by the Committee in co-operation with the Empire Parliamentary Association, the Governments of Trinidad and British Guiana and the Jamaica Imperial Association, which suggested that Lord Burnham on the occasion of his visit to the West Indies earlier in the year, might be accompanied by representatives of the Parliament of the United Kingdom.

PRODUCTION OF RESIN BY THE HARZGESELLSCHAFT.

The annual report of the Harzgesellschaft shows that in the year 1922, 127 metric tons of resin were extracted. The sources were as follows:—55,000 kilos from leased land, 51,000 kilos from the Prussian Staatsforstverwaltung (Prussian Bureau of Forestry), and 21,000 kilos from the Bavarian Staatsforstverwaltung. From this amount 88,000 kilos of finished resin and 20,500 kilos of turpentine were obtained.

The cost of production was considerably below market prices and a large profit was made, enabling the company to declare a 50 per cent. dividend and to put aside 1,500,000 marks for scientific research work. Negotiations were made with a view to obtaining new leases from the Prussian and Bavarian Staatsforstverwaltung for the two new fiscal years—one a short one from January 1st, 1923, to March 31st, 1923 and one from April 1st, 1923, to March 31st, 1924. An agreement for this purpose was signed in January with the Prussian Ministry of Agriculture, but negotiations with the Bavarian Staatsforstverwaltung did not materialize, so that the extraction of resin in Bavaria will only be undertaken by the head foresters, who, in turn, will sell the product to the Deutsche Harzgesellschaft. However, contracts for deliveries were signed last year, and both the Bavarian Staatsforstverwaltung and the Prussian minister of agriculture, domains, and forestry have given instructions to the places in question to continue the extraction of resin as quickly as possible. An agreement with Saxony is pending. The production from this part of the country is limited, owing to the scarcity of pine.

It appears from a report by the United States Vice-Consul at Frankfort-on-Main that the Deutsche Harzgesellschaft has enlarged its works and has leased new ground. At present it has 1,500 hectares (3,706 acres) at its disposal, with a sufficient number of trained employees in view. The company anticipates extracting 800 kilos of raw resin per hectare, which contains about 70 per cent. pure resin, 17 per cent. turpentine and 13 per cent. waste. Private owners have been approached with a view to obtaining leases for new resin ground

and it is hoped that they will, in one way or another, lend assistance to the industry. The outlook for the new year is quite favourable and an increased production of resin by the Harzgesellschaft is anticipated.

CHICLE INDUSTRY IN BRITISH HONDURAS.

Chicle is a crude gum used as the base in the manufacture of chewing gum. The best quality of chicle is produced in the States of Yucatan and Campeche in Mexico, in Guatemala, and in the northern half of British Honduras. This gum is derived from the sapodilla trees which grow in the mahogany forests. The average yield is from two to six pounds per tree, the maximum yield for certain regions having been stated at 25 pounds, but in Mexico and in British Honduras the yield of gum per tree is reported to have reached as high as 61 pounds.

The chicle season extends from the first of July to the end of June. In July, the beginning of the rainy season, the trees are tapped for the gum, which is then boiled, kneaded, and moulded into blocks weighing 30 pounds each, and sent to the port of shipment. Practically all of the chicle from the three principal producing countries is shipped from the port of Belize in British Honduras. According to a report by the United States Consul at Belize, the first shipment of chicle to the United States from British Honduras was in 1892. Within a few years the industry in British Honduras had assumed important proportions and has continued to develope to such an extent that it now holds first place in respect to the value of exports and as a source of revenue to the Government on account of the export duty. In 1896, 925,199 pounds of chicle were exported from British Honduras, and in 1922 exports amounted to 2,032,102 pounds. The highest peak in the interval was reached in 1920, when 3,690,641 pounds were exported.

A number of the larger American manufacturers of chewing gum have established agencies in Belize in order to buy, test, and ship the gum to the United States. The price of chicle has dropped from an average of 2s. 11d. per pound in 1920 to an average of 2s. in 1922. The quality of the gum, however, has improved notwithstanding the decrease in price. During the war and immediately thereafter, owing to the high prices asked for chicle, many of the manufacturers of chewing gum experimented with other ingredients in the hope of finding a satisfactory substitute for chicle. A cheaper gum from the Far East was used with a degree of success, but no substitute has been found which equals chicle in value.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, DECEMBER 17.. University of London, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C., 4 p.m. Mr. F. W. Twort, "The Influence of Environment on the Life of Bacteria." (Lecture IV.)

Geographical Society, 135, New Bond Street, W., 8.30 p.m. Rev. W. Weston, "The Influence of Nature on Japanese Character."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Graduates' Section). Mr. F. E. A. Manning, "The Management of a Sand and Flint Quarry."

Engineers, Junior Institution of (North-Western Section), at the Manchester Geographical Society, 16, St. Mary's Parsonage, Manchester, 7.15 p.m. Mr. H. M. Knight, "The Application of Fuel Oil to Modern Industry."

British Architects, Institution of, at the Royal Society of Medicine, 1, Wimpole Street, W., 8 p.m. Mr. R. Unwin, "Higher Buildings in relation to Town Planning."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Informal meeting.) Discussion on "Students in Electrical Undertakings."

Textile Institute (London Section), 38, Bloomsbury Square, W.C., 7.30 p.m. Discussion on "Comparative Methods of Testing Textiles."

East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Sir Alfred Chatterton, "The Future Development of Indian Industries."

TUESDAY, DECEMBER 18.. Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m.

University of London, King's College, Strand W.C., 5.30 p.m. Baron A. F. Meyendriff, "The Russian Constitution of 1905."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Mr. J. Stuart, "Tshaka, the Great Zulu Despot."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m.

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. W. Sellar, "A Basis for the Explanation of Marine Gear Troubles."

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C., 5.30 p.m. Mr. H. T. Chapman, "Arterial Roads and their Effect upon Transport."

WEDNESDAY, DECEMBER 19.. University of London, at the Royal College of Surgeons, Lincoln's Inn Fields, W.C., 4 p.m. Mr. F. W. Twort, "The Influence of Environment on the Life of Bacteria." (Lecture V.)

Metrological Society, 49, Cromwell Road, S.W., 5 p.m.

THURSDAY, DECEMBER 20.. Photographic Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Mr. Will Day, "Kinematography and its Antecedents." (Inaugural Meeting of the Kinematography Group.)

Chemical Society, Burlington House, Piccadilly, W., 8 p.m. (1) Mr. W. E. Downey, "The Relation between the Glow of Phosphorous and the Formation of Ozone." (2) Mr. T. M. Lowry, "The Origin of Mutarotation and the Mechanism of Isomeric Change." (3) Messrs. F. Challenger and F. Pritchard, "The Action of Inorganic Haloids on Organo-metallic Compounds." (4) Messrs. J. F. Wilkinson and F. Challenger, "Organo-Derivatives of Bismuth. Part VII. Iodo- and Nitro-Derivatives of Triphenylbismuthine."

London County Council, at the Geffrye Museum, Kingsland Road, E., 7.30 p.m. Major A. A. Longden, "The Modern Home."

Mechanical Engineers, Institution of (Local Section), Engineers' Club, Albert Square, Manchester, 7 p.m. Prof. A. H. Gibson and Mr. H. W. Baker, "Exhaust Valve Cylinder Head Temperatures in High-Speed Petrol Engines."

(Local Section), University Buildings, Edgbaston, Birmingham, 7.30 p.m. Mr. H. C. Young, "Engineering Uses of Rubber."

Mining and Metallurgy, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m.

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FRIDAY, DECEMBER 21, 1923.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

COUNCIL.

COMPETITION OF INDUSTRIAL DESIGNS.

A meeting of the Council was held on Monday, December 10th; Present:—

Lord Askwith, K.C.B., K.C., D.C.L. (in the Chair); Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Sir William Henry Davison, K.B.E., D.L., M.P.; Mr. Edward Dent, M.A.; Mr. P. M. Evans, M.A., LL.D.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Major Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; Dr. William Henry Maw, M.Inst.C.E.; Sir George Sutton, Bt.; Mr. James Swinburne, F.R.S.; Mr. Alan A. Campbell Swinton, F.R.S.; Mr. Carmichael Thomas; Dr. J. Augustus Voelcker, M.A., Ph.D.; Sir Frank Warner, K.B.E.; and Sir Philip Watts, K.C.B., LL.D., F.R.S.; with Mr. G. K. Menzies, M.A. (Secretary of the Society).

The Regulations for the first Annual Competition of Industrial Designs, to be held at the Victoria and Albert Museum in June, 1924, were finally approved. On this occasion competitions will be held in the following sections:—Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. Over £1,000 will be offered in Travelling Scholarships and Money Prizes in the various sections, and the Society's Diploma will be conferred on any candidate whose work reaches a very high standard of artistic ability and shows practical knowledge of the materials and processes of his trade. Copies of the Regulations can now be obtained on application to the Secretary.

Adjudicators for the Swiney Prize were appointed.

Arrangements for papers to be read in the last part of the session were further considered.

Other formal business was transacted.

SIXTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 12th, 1923; SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Alexander, Philip, London.
Fletcher, John Kyrle, Newport, Mon.
Graydon-Bradley, Mrs. E., London.
Margerison, William Joseph, Leeds.
Rhead, Frederick A., Wolstanton, Staffs.

The following candidates were duly elected Fellows of the Society:—

Avram, Möis H., New York City, U.S.A.
Davis, Neville Ryland, London.
Duitz, Emile A., Amsterdam, Holland.
Gray, Roland, Boston, U.S.A.
Lang, Reginald, Plymouth.
Morrow, George Leslie, Berkhamsted, Herts.
Rayner-Smith, Percy, London.
Williams, Lennard, Tilehurst, Berks.
Williams, Stephen Miller, Arkansas, U.S.A.

A paper on "The Preservation of Historic Buildings and Ancient Monuments" was read by SIR FRANK BAINES, C.V.O., C.B.E., Director of Works, H.M. Office of Works.

The paper and discussion will be published in a subsequent number of the *Journal.*

DOMINIONS AND COLONIES SECTION.

MONDAY, DECEMBER 17th, 1923; THE EARL OF AIRLIE, M.C., in the Chair.

A paper on "Empire Settlement" was read by Mr. Wm. C. NOXON, Agent-General for Ontario.

The paper and discussion will be published in a subsequent number of the *Journal.*

MANN JUVENILE LECTURES.

Under the Mann Trust a short course of lectures adapted to a juvenile audience will be delivered on Wednesday afternoons, 2nd and 9th January, 1924, at 3 p.m., by DR. WILLIAM ARTHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology, on "Fire and Explosions." The lectures will be fully illustrated with experiments.

A lecture will also be given on Wednesday, January 16th, at 3 p.m., by MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, entitled "Among the Selkirk Mountains of Canada (with ice-axe and camera)." The lecture will be fully illustrated with hand-painted lantern slides.

Special tickets are required for these two sets of lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to a ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once stating for which lectures the tickets are required.

PROCEEDINGS OF THE SOCIETY.

FOURTH ORDINARY MEETING.

WEDNESDAY, NOVEMBER 28TH, 1923.

LORD DAWSON OF PENN, M.D., B.Sc., F.R.C.P., in the Chair.

THE CHAIRMAN said that the audience was to enjoy a disquisition by a master of his subject on the scientific application of three great natural agencies—namely, air, water, and sunlight, which belonged to man's environment (though the experience of the last few days might create a fear that light was no longer one of them). The beneficial effects of climate, sunshine, and life by the seaside, belonged to the common experience of mankind. What had not been apparent was the how and the why of their actions, so variable in their effects on different people. They had only to try and imagine the world without sunshine to bring home to their minds not only the necessity of the sun to human existence, but the part it played in giving activity, joy, and laughter. All this had been known and applied in a loose empirical way for ages. Then came method and scientific application. For bringing intensive sunshine and air into a system of treatment a great debt was due to Dr. Rollier, who, at his clinics at Leysin, amidst beautiful surroundings and abundant sunshine, brought healing and happiness to hundreds every year. Then in our own country arose the late Sir William Treloar, a man of vision, hope, and heart, who showed the supreme quality of youth in age, and for whose life they were grateful, and for whose death sorrowful. Treloar conceived the idea of treating child cripples, so many of whom were tuberculous, by air and sunlight, and he had the good fortune to press into his service Sir Henry Gauvain, who combined scientific distinction with skill in administration. It required faith and courage to organize such a scheme in our country, where the sun showed itself so fitfully, and sometimes so little, and where winters were apt to be gloomy and sunless. But it had been accomplished, and with that accomplishment under the climatic conditions of this country the proof of the success of the treatment was the stronger. Let anyone who had not already had the pleasure of doing so pay a visit to Alton or Hayling Island. There they would see sickly children made whole, helpless children made useful, and children so uniformly happy and mirthful as to bring sunshine to all who saw them. The great results which had followed the systematic use of sunlight and fresh air in this and other countries had stimulated research as to the means whereby light exercised these beneficent actions. The ultra-violet rays would appear to raise the resisting and fighting power of the blood against infection, thereby opening up a possible field of successful treatment of many diseases at present baffling. But here caution was necessary, for already there had been ample evidence to show that any application of such treatment beyond what careful research had indicated was likely to inflict harm and not good. In short, like all effective weapons, they could be powerful alike for healing and for destruction. The influence of light upon the growth and vigour of the young had yielded the most fascinating results. Sir Henry Gauvain would give his experience, and the brilliant researches by workers sent out by the Medical Research Council to Vienna to inquire into the influences of light on the cure of rickets stood out as landmarks in our knowledge. If he allowed himself to indulge in prophecy he would say that both in the region of diagnosis and treatment there was no direction in which the power of knowledge over health and disease would be more prolific of results within the next few years than in the scientific utilization of the action of radiations and the action of air. When the world realized the power of daylight in the maintenance and restoration of health, was it to be supposed that public opinion would longer suffer tens of thousands of town dwellers to be immersed in eternal gloom to the detriment of their health and energies and to the saddening of their lives? When once the gain in effectiveness and happiness afforded by light and air was understood, smoke abatement would be insisted upon, the demand for clean air would give such an impetus to investigation that a way out would be found against the smoke nuisance which would furnish the prime necessity of health without any undue crippling of industry; and just as years ago a great movement of public health gave us the blessings of pure water, pure food, and good drainage, so the public would demand and support a like campaign for the equally vital blessings of light and air.

The paper read was:—

THE EFFECT OF SUN, SEA AND OPEN-AIR IN THE TREATMENT OF DISEASE.

BY SIR HENRY GAUVAIN, M.A., M.D., M.Ch.,

Medical Superintendent, Lord Mayor Treloar Cripples' Hospital.

It is perhaps of academic interest to note that sunlight has been used spasmodically and to some extent in the treatment of disease from the earliest times. There has long existed an almost instinctive recognition

of the value of sunny localities and sunny climates in the treatment of the sick, particularly during convalescence. But for real practical purposes the solid value of light treatment commenced with Finsen, and the sun cure, as we now recognise it, only dates from this century, and owes much for its systematic app ication to Rollier, its first really enthusiastic advocate, who opened his first clinic in Leysin in 1903.

Quite unconscious of Rollier's work I first noted the value of sunshine in 1908, started treatment in 1909, and became really enthusiastic during the fine summer of 1911, since which date it has been employed systematically for every suitable patient at Alton. I first heard of Rollier and his methods in 1912. I mention this because it is of historic interest to note that the sun cure was evolved independently in this country and, as far as I am aware, first utilised in England at Alton. Comparatively little interest was evoked until 1921, when the most wonderful summer in living memory, coupled with increasing advocacy of an extended summer time, compelled universal notice in England of the effects of abundant sunshine, and directed an almost embarrassing attention to our work at Alton. Quite suddenly this method of treatment attracted widespread notice and nobody was more surprised than we were at the interest aroused in our work, which had been carried on for years in almost unnoticed obscurity.

It is a comment on the human powers of deduction that while the tonic stimulus following exposure to sunshine, open air and sea-bathing, had been accepted instinctively, so little had been done to employ these natural therapeutic agents intensively and in the cure of disease, or enquire into the manner in which they could all be utilised systematically for treatment in appropriate cases.

Indeed I must confess that we physicians who were using sun treatment with success were to a large extent employing it empirically. We recognised that, carefully practised with suitable precautions, we had in our possession a wonderful aid to cure. We knew that certain effects could be constantly anticipated. We obs rved that the patients who tanned well generally did well; that the greater the area of skin that could be exposed the better for the patient; that the blood became richer in quality and anaemia disappeared; that the metabolic activity of our patients increased to a surprising extent and atrophied limbs swelled out and acquired muscular tone, associated rather with the athletic than the bedridden; that the mental condition of the patient imp oved, and the modern sun-worshipper was the happiest and brightest of mortals, in strange contrast to the peevish and irritable creature drawn from dingy urban hospital wards. Strangers perhaps, even more than we practitioners, drew attention to the robust health of the patients who, treated otherwise, were pallid, listless and apathetic, and marvelled accordingly. Visitors would constantly remark that they had anticipated that a visit to the Hospital at Alton would reveal sorrow and depression, but that nowhere had they seen healthier looking or happier children, abounding in animal spirits. On local lesions we soon discovered that no longer was it necessary to swathe wounds in costly dressings, but exposed to the sun they changed in character, became no longer foul and healed in spite of surgical aid, not because of it.

Gratifying as it was to note these phenomena and see returning health rapidly transform our patients, it was a corrective to conceit for one perceived that it was due to the employment of these free and natural aids to cure and not due to surgical skill or medical knowledge. Many other clinical efforts might be noted, but with these I need not detain you. But how were these results obtai ed? Only slowly was the question being answered, but recently a great a k it on has been made to our knowledge, chiefly by the labours of pure scientists, physiologists and others, amongst whom the names of two call for especial praise—Professor Leonard Hill and Dr. Sonne. One fact demands special notice. In the recent expansion of scientific knowledge, treatment of disease has been generally based on the researches and investigations of the laboratory worker. They discover principles and we clinicians then apply them in practice.

But in sun treatment, in sea-bathing and in the therapeutic use of open air, the reverse has taken place. Here I am glad to say clinicians have led. In the face of opposition, criticism, scepticism, or even worse, indifference, we have employed these aids to cure and the results have compelled attention and investigation. It has been especially interesting to me to note the changed attitude that has followed these investiga-

FIG. 1.—On the balconies at Alton. Sun and Shade Treatment.

tions, a change based on discoveries of profound importance, which discoveries will enable us to apply those methods of treatment with greater assurance and certainty, and make their application an exact science where formerly it was empirical practice.

In the short time which your kindly attention will permit I can perhaps best and most briefly describe the therapeutic action of sunlight under three headings: 1, Its psychological a tion on the mind; 2, Its direct or local effect; 3, Its indirect or remote action.

Of the first I will say little other than that sunlight has a powerful stimulating and tonic effect. It exhilarates and enlivens. It induces gaiety, liveliness and a sense of well being. It braces up and cheers the soul. Like all stimulants, if pressed to excess it intoxicates and then exhausts. Its action may not be unfairly likened to a draught of good champa ne.

Norman Davey well describes the effect of sunshine when he says:—

"The sun is a dispeller of ill-humours. He is the healer, the life giver. He is the only true doctor to the troubled mind. He is the best apothecary in the world. There is no tonic sold for gold over any chemist's counter so remedial as that celestial pick-me-up which is poured for nothing at daybreak, over that wide counter which is the rim of earth."

Not only is the vivacity of the patient increased, but his mental capacity is also raised and testimony to this is provided by the reports of teachers engaged in instructing children in "Schools in the Sun."

(2) The local or direct action. Sunlight has a powerful direct bactericidal action. It has been described as the world's great antiseptic. This property is especially strongly possessed by the ultra-violet rays in the sunlight. Unhap ily, the direct bactericidal action of light is strictly limited as the ultra-violet rays have very little penetrative power. They do not even traverse the human skin. The tubercle bacillus exposed to its direct action is speedily slain, but the penetrative power of the light is so limited that it is said that a similar bacillus, lying directly under the one exposed, would be protected and survive. When we consider how minute an object the tubercle bacillus is we can realise the limitations of light in this respect. Nevertheless it may be usefully employed for its direct action on local lesions. Unprotected organisms lying on the immediate surface of a wound will be slain, those more deeply situated are attacked by the beneficial inflammatory action which exposure to light, adequate in intensity and suitably timed and controlled, may provoke. In blanched anaemic tissues its penetrative action is increased and this fact is utilised in the Finsen light, where the lesion attacked is rendered anaemic, and an intense source of ultra-violet radiation is employed. In this way lupus, that disfiguring manifestation of cutaneous tuberculosis, may, if not too deep seated, be successfully treated.

(3) The indirect or remote action. The study of the remote effects of sunlight constitutes the most fascinating problem presented to the heliotherapeutist. Why and

how can deep-seated lesions protected by a mass of superjacent tissue which by no conceivable means can be reached by ultra-violet radiation, be favourably influenced ?

Let me give some examples of such conditions which may be favourably influenced and even cured by the action of the sun's rays, and here let me again state that these effects have been produced for years by means which we had not been able to explain.

(*a*) A patient had recurring attacks of severe stomatitis,—inflammation and ulceration of the mucous membrane lining the mouth. The condition proved very resistant to treatment and always recurred. Three exposures of the patient's back —not mouth please note—were given to a source of ultra-violet radiation. All the ulcers were soundly healed within one week, the stomatitis cured and the trouble has not recurred.

(*b*) A patient suffered from severe neuritis for years. No source of sepsis was discovered. No treatment was of any avail. Two exposures to ultra-violet light removed the pain and after five exposures the patient felt quite well and the condition has remained cured.

(*c*) A patient had symptoms of intestinal ulceration and later of obstruction. Laparotomy was performed and at the operation an intussusception was found which was reduced. In the abdomen was discovered a mass of mesenteric glands which it was deemed unwise to remove. After a course of sun-treatment during one summer the patient became completely well and remained cured.

(*d*) A patient suffered from multiple pyaemic abscesses of bone, and septic arthritis of the hip-joint. The casual organism was the staphylococcus. Numerous operations leaving sinuses had to be performed. One summer's sun cured all.

I could multiply such examples by hundreds, but need not weary you. But how can we explain these cures ? Recent research has thrown much light on the subject. For the explanation it is necessary for us to analyse the effects of the various wave-lengths of the solar spectrum. The solar spectrum consists of rays of varying wave-lengths, the infra-red, the luminous and the ultra-violet. The wave-length decreases in the order named and the penetrability likewise. The infra-reds especially heat the surface of the skin and produce severe superficial inflammation, even charring if exposure to a strong source is prolonged. Sonne has shown, by a series of very remarkable experiments, that the luminous rays have considerable penetrative power, are absorbed by and heat the blood-stream. Indeed their heating effect is so great that the blood may be locally raised to a very high temperature. By means of a thermopile inserted into a vein draining the irradiated surfaces he recorded temperatures of 115°F. Had the body generally been raised to such a temperature the effect would have been fatal but the body temperature is raised little above the normal, for the heated blood passing into the portal system is rapidly cooled. Remarkable also is the fact that though the blood beneath the irradiated skin is so hot, the temperature of the skin itself is only slightly raised. Now at such temperatures as this many bacterial toxins are said to be destroyed and the obvious step to take next was to see what effect was produced on such toxins injected into an animal. Accordingly lethal doses of diphtheria and typhoid toxin were injected into rabbits and guinea-pigs. Certain of these were irradiated with luminous rays from a carbon arc, others not irradiated remained as controls. Many of the irradiated animals survived, the controls died. It does not need a scientific mind to foresee what an enormous influence such a fact may have in its practical application in medicine.

Remarkable as were Sonne's observations I have others even more striking to announce. Only last month investigations were commenced by Professor Leonard Hill, Dr. Eidenow and Dr. Colebrook to ascertain if exposure to light rays had an effect on the power of blood to destroy micro-organisms. The haemobactericidal power of the rabbit is naturally very low. This animal was accordingly chosen and the organism selected for test was the staphylococcus, one of the most frequent of the micro-organisms infesting wounds. The blood of rabbits after exposure to sunlight, carbon arc, mercury vapour lamp and cadmium arc (the two latter especially rich in ultra-violet rays) was found then to have enormously increased bactericidal power. The further interesting observation was made that the bactericidal power of blood irradiated after being drawn was not increased, the increase only occurred after irradiation through the living tissues of the animal. The significance of these observations is very great. They, of course, need confirmation, but that will be certainly forthcoming. They need investigation in

FIG. 2.—Tuberculous Disease of the Spine, before Treatment.

FIG. 3.—The same Patient with Disease arrested and Deformity corrected.

man but that also will be easy. But if confirmed in man, as I have little doubt they will be, a great and entrancing new chapter in therapeutics will have been opened. The manner in which sunlight acted on those cases I have described may probably be thus explained.

But confirmation of this property of ultra-violet light must be obtained and I would utter the warning that we must await patiently such confirmation which will certainly be speedily forthcoming or the fallacy, if one exists, exposed. The increased haemobactericidal power in rabbits remains for some two hours after exposure but may be repeated apparently indefinitely by further exposures.

Other functions of ultra-violet light I must not delay to describe: how it causes pigmentation of the skin and the prognostic,

protective and other functions of that pigment: how it is a food sparer inasmuch as it will replace vitamines in a vitamine free diet and thus prevent or cure rickets; how it has an extraordinary analgesic power and can thus be utilised in the relief of pain (possibly this is but a result of its specific bactericidal power—future research can alone determine that).

There appears to be an antagonistic action of one series of waves of sunlight to others. Thus Professor Hill has shown that paramoecia exp. sed to a definite dose of ultra-voilet radiation are slain in a constant time. The addition of luminous rays markedly lengthens the lethal time and thus I suggest it is possible that harmful effects are guarded against in the varying wave-length of the solar spectrum. Pigment formed in our skins on exposure is also protective and thus longer exposures may be safely tolerated in the pigmented than in non-pigmented. During such polonged exposure the luminous rays continue their beneficent action, heating up the blood and thereby helping the ultra-violet rays to increase its bactericidal action.

In short, continued research but confirms Vignard's picturesque simile: "the skin becomes a vast keyboard on which the light strikes, awakening deep resonances throughout the body."

In the light of these recent investigations it becomes necessary and increasingly hopeful to modify technique in applying sun-treatment.

The value of the natural sun cure as at present practised is confirmed by weighty scientific evidence, but it may be enhanced and improved by logical utilisation of known facts experimentally obtained.

Professor Hill has devised an instrument by which the biological action of light may be accurately measured, and it now is possible to give definite known doses of ultra-violet light designed for particular purposes, instead of, as formerly, merely guessing from clinical observation and experience the amount of light which should be employed.

To the natural sunlight, which is likely to remain the best method of treatment for many cases, may be added particular radiations for especial purposes. Various wave-lengths may be utilised separately or in combination. Thus a very septic patient whose blood is swarming with pathogenic organisms and who is toxic to a dangerous degree may conceivably be first usefully irradiated with luminous rays to destroy dangerous toxins. Next he would receive ultra-violet light to increase his haemo-bactericidal power to slay living germs. Again, he would be irradiated with luminous rays to destroy the toxins liberated in the destruction of the pathogenic bacteria. Local superficial lesions might then be irradiated with infra-red rays to increase local inflammatory response and engorge these tissues with blood of high bactericidal power, and constantly natural sun baths over continous periods may be given to combine all effects and for their psychological value. Finally, as the patient can stand it, seabathing with the definite object of raising high his metabolic activity may be given, and other combinations of these natural therapeutic aids employed as individual requirements indicate.

On these lines the future light treatment at Alton will be conducted. There is obviously urgent need for extensive clinical research. By the generosity of Mr. Courtauld, to whom I would express my grateful thanks, a handsome donation of £1000 has been given to the Treloar Cripples' Hospital, earmarked for scientific research and apparatus, and the initial necessary apparatus is being purchased for the establishment of a great light department at Alton which I have long desired but have hitherto for financial reasons not been able to obtain.

I have occupied so much time in describing developments in light treatment, important and essential though they are, that my further remarks on open-air and sea-bathing in treatment must necessarily be very curtailed.

These subjects are themselves so important that the whole of the time at my disposal could have been profitably employed in their consideration alone.

Exposure to the sun has been known to be associated with increased metabolic activity in patients treated, and was formerly supposed to be the result of insolation. That may be partly true, but Professor Hill and Dr. Argyll Campbell after extensive investigations on our patients at Alton and Hayling Island, have demonstrated that this high metabolic activity, or increased capacity for work and tissue change, developed in these patients following sun-treatment, is due rather to exposure to cold air than to light. With insolation

Fig. 4.—After the Bathe. Patients are dried in the pens before the radiant heat of a fire, their feet are put in hot water, and they are given a hot drink. This is for the purpose of obtaining a brisk reaction. Patients then receive a sun-bath.

such exposure to the air necessarily occurs, and increased metabolic activity was not unnaturally ascribed to the action of sunlight.

It was found that patients who pigmented well could tolerate exposures to sunlight for lengthier periods than non-pignenting patients, but the increase of metabolic activity was common to each class provided both were exposed equally to cold air. The progress made by good pigmenters was usually more rapid, and their average body weight higher than that of non-pigmenters, but increased metabolic activity was common to both, and was greater in winter than in summer. It is much higher in old patients acclimatised to the open air than in new. The further important observation was made that it remains high for a considerable period after exposure to open-air ceases. Thus the effect is a lasting one, and the benefits of such treatment remain for a considerable time after exposure has ceased. The effect of this high metabolic activity is to encourage tissue change. Greater oxygenation is effected. There is a greater ability of the patient to exercise his powers of response to stimuli. More body work is done, more food has therefore to be consumed and digested and generalised improvement becomes speedily manifest. It is important to note that there is an optimum metabolic activity, varying in individuals but which should not be exceeded. Excessive exposure to cold leading to shivering is not only unnecessary but actually cruel and harmful, and should always be avoided. It is, however, noteworthy that in well pigmented patients a considerable degree of cold can be borne not only without discomfort, but with very definite benefit. In very young patients, in the feeble and cachectic, and in the aged, great care must be exercised, and only very gradually should this treatment be attempted. In the vigorous, however, exposure to cold air is well tolerated, and when properly dosed not only causes no discomfort but is highly beneficial. The improvement in bodily tone and in general condition under specially graduated aerotherapy is remarkable especially when the long period of immobilisation in splints of those suffering from bone and joint disease is considered. The average basal metabolism of our immobilised patients is about 40 per cent. above that of the normal child. While exposure to cold air is gradually effective in securing an increased metabolic activity, paddling in the sea, spraying with sea water or total immersion affords us a means of very rapidly, accurately and, with due precautions, safely, obtaining similar results. Indeed metabolic activity during sea-bathing may, and often is,

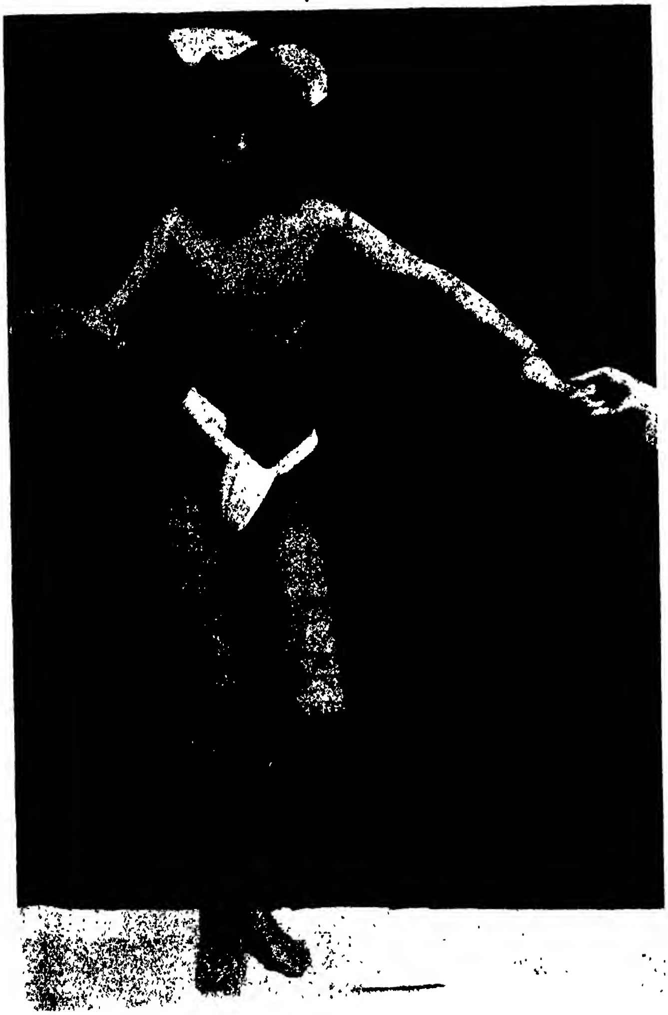

FIG. 5.—Tuberculous Disease of he Hip and Pubes.

FIG. 6.—Same patient after Sun, Sea and Air Treatment. Note the excellent muscular development.

raised no less than 1000 per cent. above the normal. We thus have a very ready means of rapidly and intermittently increasing tissue change and stimulating heat production. This enhanced working capacity of the body is of great value to the patient suffering from surgical tuberculosis.

The stimulating effect of a sea bath in the open is much greater than of a bath in river water. Immersion is followed by deeper respirations which effectually expand the lungs and expel waste products. The circulation is profoundly modified. The first chilling effect causes contraction of the superficial capillaries, followed during the reaction stage by their dilatation. All parts of the body are, in phases, flushed by an increased volume of blood and lymph, which exercises its healing action on diseased bones and tissues. There is added excretion from the lungs and kidneys, and later from the skin, as well as absorption by the skin. Properly timed sea-bathing, followed by brisk towelling and a graduated sun bath, produces a sense of exhilaration and well-being which nothing else can convey. The amount of food consumed by the patients at Hayling Island during the bathing season is much greater than the proportion used at Alton, and is followed by marked muscular development and increase of tone.

On local lesions the effect is yet more striking. Discharging wounds secrete at first more; but the character of the dis-

charge is changed, it becomes less purulent and more serous. The diseased tissues are flushed with lymph, which under the influence of the sun has acquired great bactericidal power. Later, the discharge diminishes, and in a large number of cases the sinuses dry up and leave supple and healthy scars. Fibrous tissue, which is fixing and rendering useless diseased joints, tends to become absorbed and movement regained. The improvement both general and local is, in suitably selected cases, rapid and striking.

Sun Treatment is more effective at the sea-side than inland. The mirror surface of the sea reflects the actinic and luminous rays but absorbs the heat rays. For some patients the stimulus at the seaside is too great, their powers of response are inadequate. This is especially true in the more toxic and younger cases. For these, inland treatment is to be preferred. But in the majority of cases alternation between inland and marine treatment provides the best and most speedy results, and the ability to obtain it greatly increases our powers for good.

CONCLUSIONS.

Bacteriological research, though of supreme and incontestable value, has had the effect of perhaps too much concentrating our attention on the cause of disease rather than on the patient attacked. We have assiduously studied the seed but neglected the soil. May I illustrate my meaning by simile? There are plants of the mountains, the plains and the marshes. A mountain plant put in a marsh would soon die and *vice versa*. A potato would not flourish in a marsh, but drain the marsh and make the soil suitable and you may secure an abundant crop. The bacteria which attack us are but minute parasitic plants. To restrict or prevent their growth the soundest logic is so to change the nature of our bodies that they cannot successfully propagate or multiply. The methods of treatment I have described to-night are methods designed to this end. Doubtless, many other means will be discovered but here, at any rate, utilised wisely, exist means which nature freely places at our disposal and which need to be developed and widely used.

I have been at Alton now over 15 years. Colds and catarrhal conditions are almost unknown even in this bleak November weather. I cannot recollect one single patient having contracted broncho-pneumonia or even simple bronchitis. A change has been effected in their constitutions which prevents such conditions arising. I maintain the lesson to be learned is not to confine such advantages to our patients but make them generally available. Schools in the sun for weakly and healthy children should become general. Insolation during convalescence in isolation Hospitals would do much to prevent more serious infections which are notoriously deadly at a time when the danger of such infections is greatest, and little imagination is needed to suggest wide and general applications of the principles I have laid down. But while advocating this I feel it is my duty to warn those interested that these measures must be wisely and carefully introduced. Graduated exposures are essential and all needed precautions should be taken or methods of great hope and promise will inevitably fall into disrepute.

(At the conclusion of his paper Sir Henry Gauvain showed a long series of slides illustrating the treatment of patients at the Lord Mayor Treloar Cripples' Hospital.)

DISCUSSION.

MR. A. J. GREEN (L.C.C. Open-air Schools) said that, as he was only a schoolmaster, he felt rather doubtful whether he ought to make any remarks before such an audience containing several well known experts in this particular line. But he had this in his favour, that he was master of the first or almost the first open-air school in London He had been in this department of the London County Council service for fourteen years. Last year Sir Henry Gauvain came to Stowey House Open Air School, Clapham Common, and suggested the starting of a sun-cure class. Although the past summer, from the climatic point of view, was an appalling one, it was possible just to get the experiment in. The month of June and a part of July were available and even in that short time the results of this sun-cure class held on Clapham Common would amaze the audience. The class consisted of thirty-six youths from the slum areas of South London, such as the Borough and Bermondsey, the New Cut, and the Lower Marsh. They came into the garden of a private house on Clapham Common, and ran about in very short shorts and no shirts, and just socks and clogs. They were in the open all day long, and the result, thanks to Sir Henry Gauvain, was highly successful. The children became much more alert, their mental capacity certainly increased, as also did their appetites, and he looked forward next year, given a better summer,

to an extension of the experiment with still more remarkable results. He was very proud to have been invited to Alton to see Sir Henry Gauvain's work at close quarters. It was a glorious work he carried on there. The children were amazing, and if anyone present had not seen them he should certainly make a point of doing so. He himself had been in open-air school work for fourteen years, and he thought his children were happy, but his children were a "wash-out" compared with Sir Henry Gauvain's. He had never seen nything which could approach the cheeriness and brightness of the children at Alton.

Dr. Rushton Parker said that he had been associated for twenty years with a sanatorium for consumption in the Lake District, and he could corroborate everything that Sir Henry Gauvain had said. One very severe winter—and winter was exceptionally severe in the Lake District—a stranger came at Christmas to look round the sanatorium and he made the remark that one problem at least which confronted the mother of a large family had been solved, for here were patients in a severe winter, each of them sleeping in an open air shelter under one blanket, and quite unable to tolerate two. The fact was that they were so thoroughly well fed that they were able to keep themselves warm by their own internal heat and could bid defiance to the climate. While he was in practice one of his horses got a very large abscess in the neck. He himself did not pretend to be able to extend his medical practice to animals, and so he put the horse under the care of a veterinary surgeon. After six weeks of cutting with knives and so on, there was no improvement, and so he took the animal away from the care of the "vet," hired a field, turned the horse into it, and did nothing else. In a very few weeks that horse got perfectly well. There was, however, one point that puzzled him. While he believed in open-air treatment and sunlight, how was it that fish got on so well at a depth of 2,000 fathoms, where they had no sunlight whatever? In the Natural History Museum there was a case-full of fish taken from that depth, and apparently they had been flourishing and had had very good appetites.

Dr. H. Chick said that she had been watching Sir Henry Gauvain's photographs with the liveliest admiration, and had also been greatly interested in the introductory part of his lecture. As one who had had a little experience of laboratory work on this subject, she felt that on the laboratory side they were still only on the threshold as yet, simply groping in the dusk. They hoped that the years would reveal something, but at present all was misty and dim. And sometimes the laboratory worker was inclined to envy people like Sir Henry Gauvain who could see the results before their eyes. She remembered in Vienna, when observing some young infants with rickets, being thrilled on more than one occasion by the sudden improvement shown in the monthly or weekly X-ray photographs of their bones following an exposure to the sun. It was the month of March, and as often happens at that time of the year in Vienna, the sun was streaming down although the air remained cold. Under such conditions the children were put out on the verandah, and within twelve days one of the infants showed a marked calcification of the rachitic bone as testified by the X-rays. This was accomplished without the slightest alteration in management or diet except that instead of being in a well-lighted and well-aired ward, the child was put out into the rays of the sun. Those were the sort of thrills that did not come quite in the same way to the laboratory worker. Her admiring congratulations were tendered to Sir Henry Gauvain for his wonderful results.

Mr. J. G. Thornton asked whether these methods of treatment were likely to be of advantage to the old as well as the young.

Miss Beadon said that she felt the more interest in what Sir Henry Gauvain was doing because in 1903 she and four other ladies set up a sort of sun-cure in Hampshire, quite close to Alton. The arrangements were very rough, but still some most wonderful things were achieved. The beginning of her interest in this matter was through being taught while at Nice, at a private international conference there, when she was quite a girl, the value of sunlight as a curative agent. The conference was held at the house of Mr. George Bishop, whose philanthropy had done so much for tuberculous patients and also for patients on the borderline. In 1900 she applied the same principles among some people in Wales, and in every single case the result was perfectly astounding. She herself was one of the last patients that Sir William Jenner saw, when she was only twenty-two. She was pronounced tuberculous, but she went out to the Isle of Wight and once or twice to Switzerland, taking the sun treatment, and she had never had a doctor since, except for slight accidents.

The Chairman (Lord Dawson) said that he was sure he was expressing the feeling of the entire audience when he thanked Sir Henry Gauvain for his most informing and encouraging lecture. His words must have brought to everyone present a feeling of gratitude and of hope. They would ask themselves earnestly how far these results would shape the treatment of the sick in future. One thing which this subject brought home to them was the need for a greater development of hospitals outside our cities instead of within them. With more hospital accommodation established in the country, it would be necessary to keep patients in the city hospital for a much shorter period than at present; cases which involved a long stay in hospital would be removed by a regular

system of organisation further out. In the matter of education and preventive medicine, which were associated, the paper must also raise some very serious considerations. He called upon the meeting to accord a hearty vote of thanks to Sir Henry Gauvain.

The vote of thanks was passed unanimously.

SIR HENRY GAUVAIN said that he was deeply grateful for the very kind reception that had been given to his remarks, and he thanked Lord Dawson especially for the great honour he had done him by coming there that evening. He felt very much indeed the value of his approbation in this work; it was an enormous encouragement to those engaged in heliotherapy. He thanked Dr. Chick for her more than kind remarks, and he wished to say how much he appreciated the wonderful work she had done in Vienna. She had opened up a new chapter in the treatment of rickets. One or two questions had been asked in the course of the discussion. Mr. Thornton had inquired whether these methods of treatment were applicable to older people. They were, but in the very aged, as in the very young, it was necessary to be careful, for they could not stand sudden exposure to extremes. Adult cases were, however, being treated by his friend Dr. Wood. He remembered the place Miss Beadon had mentioned, close to Alton, quite well, and she was entitled to special congratulation because her work synchronized with that of Dr. Rollier, at Leysin. The testimony of Mr. Green, a headmaster of long experience, as to the value of "schools in the sun" on the mentality of children, was valuable and encouraging.

The proceedings then terminated.

THE NEWCOMEN SOCIETY.

The Newcomen Society was founded in 1920 for the study of the history of Engineering and Technology. It is a subject which has certainly been much neglected in the past: while history has lavished her attention on the great soldiers and statesmen of the world, she has taken small notice of the engineers and inventors, whose labours have been mainly responsible for the world's advance in material well-being. The Newcomen Society aims at remedying this evil, and has amongst its objects the following:—(1) To disseminate historical information among its Members by meetings, intercourse, discussion, correspondence, circulation of notes and papers, and visits to objects and places of interest; (2) To act as a channel of communication between Members who are engaged on similar lines of research or study; to indicate as far as possible where information is to be found; (3) To collect and preserve or cause to be preserved, locally or nationally, examples, records, MSS., drawings and illustrations of or relating to engineering work and industrial processes; (4) To collect and preserve in a similar way biographical matter concerning those men who have contributed to engineering or industrial progress; (5) To print and issue to Members each year a volume containing original memoirs by Members, bibliographical notes and historical material not generally accessible; (6) To form by collaboration among its Members a card index of published information on the historical aspect of engineering and technology.

Two volumes of the Society's transactions have now been published, for 1920-21 and 1921-22, containing between them some fifteen papers, dealing with a great variety of subjects. Mr. Loughnan St. L. Pendred, now the President of the Society, contributes an interesting article, entitled "The Mystery of Trevithick's London Locomotives." It is remarkable that, in spite of the enormous influence exercised by Trevithick's work in the development of the steam engine, you may, as Mr. Pendred says, "search all the magazines, encyclopædias, and books on the steam engine issued during the first fifty years of the 19th century and find no more facts about Richard Trevithick and his work than would fill a column of *The Times*." Unfortunately much the same may be said about most of the world's great engineers and inventors, and this fact alone justifies the addition of one more to the already appallingly long list of learned and scientific societies.

Not the least interesting among the papers published in these volumes are those which deal with some of the earliest mechanical inventions. Thus, Mr. G. F. Zimmer, in "The Early History of Mechanical Handling Devices," shows a picture of an "Animated Bucket Elevator," taken from an alabaster slab in the British Museum, c. 700 B.C., while Sir George Greenhill, in the discussion following this paper, recalls a feat of Archimedes, c. 250 B.C., in hauling a laden ship over dry land. Mr. R. C. Skyring Walters gives an account of Greek and Roman engineering instruments, the excellence of which will surprise many engineers of to day, and help to explain some of the marvellous tunnelling feats mentioned in the paper. Mr. East Lones' account of "Mechanics and Engineering from the time of Aristotle to that of Archimedes" shows that engineering, like almost every other science and art, owed an enormous amount to the genius of the Greeks.

A word of praise must be added in recognition of the admirable manner in which the Transactions are printed and illustrated.

LA VIE INDUSTRIELLE EN FRANCE.

[The Council are of opinion that it would be useful to Fellows of the Society to publish a series of notes of important industrial developments in France. Through the kind offices of the Société d'Encouragement pour l'Industrie Nationale they

have been fortunate in securing the services o Monsieur Paul Calfas, Ingénieur des Arts et Manufactures, who will contribute such information from time to time.]

LES TURBO-ALTERNATEURS DE GRANDE PUISSANCE DE LA SOCIÉTÉ ALSACIENNE DE CONSTRUCTIONS MÉCANIQUES.

De même qu'en Angleterre et aux États-Unis, le besoin s'est fait sentir en France, d'employer, dans les stations centrales électriques, des groupes électrogènes de puissance unitaire très élevée. En même temps, on a augmenté la vitesse de ces groupes électrogènes, le plus souvent actionnés par des turbines, de façon à en augmenter le rendement et à en abaisser le prix.

Nous prendrons comme exemple de ces perfectionnements récents, d'après les renseignements donnés par M. Roth, ingénieur en chef de la Société Alsacienne de Constructions Mécaniques, les grands turbo-alternateurs à vapeur que construit cette Société dans ses usines de Belfort. Sa plus belle fabrication, jusqu'ici, est représentée par les groupes de 45.000 kva, tournant à 1500 tours par minute, qu'elle a installés en 1922 à la supercentrale de Gennevilliers, près Paris. Cette usine appartient à l'Union d'Electricité, et fournit le courant à toute la région parisienne.

Les problèmes à résoudre dans la construction de ces turbo-alternateurs sont à la fois d'ordre mécanique et d'ordre électrique. Le rotor cylindrique, massif ou lamellé, est encoché par fraisage ou par étampage, de façon que les dents font corps avec la masse du rotor. L'acier employé pour celle-ci, ainsi que pour l'arbre rotatif, est un acier au carbone supportant un effort de rupture de 50 à 55 kg. : mm2 avec une limite élastique de 35 à 40 kg. : mm2, et un allongement de 18 à 20%.

Pour le refroidissement des enroulements par ventilation, dans les très grands alternateurs, la Société Alsacienne emploie un système mixte consistant à faire passer l'air radialement dans les évidements du rotor, et à le faire circuler axialement dans le fond des encoches du stator, qui sont plus creuses que ne le comportent les enroulements. L'air échauffé est ensuite refroidi par de l'eau, par exemple l'eau sortant du condenseur.

La protection des enroulements contre les effets des courts-circuits est souvent obtenue au moyen de bobines de réactance extérieures à la machine ; mais, dans les grands alternateurs modernes, on supprime ces bobines et on donne à la machine une grande réaction d'induit, ou bien on augmente artificiellement les fuites ; en outre, on consolide fortement les têtes de bobines : la Société Alsacienne emploie concurremment ces divers procédés.

LA CONSTRUCTION AUTOMOBILE FRANÇAISE ET LA SALON DE L'AUTOMOBILE DE PARIS. (Octobre-Novembre 1923.)

La construction automobile française s'est de nouveau brillamment affirmée au dernier Salon de l'Automobile. L'année 1923 aura vu mettre en service plus de 120,000 voitures neuves, et la petite automobile populaire fait rapidement son chemin. Nos plus grandes firmes : Citroën, Renault, Peugeot, Voisin, etc., lancent dans le public des voiturettes de 5 à 8 chevaux, assez bon marché (10,000 à 12,000 francs), très bien construites, commodes, légères, et de conduite facile, grâce au démarrage électrique.

D'autre part, la voiture de luxe et de forte puissance continue à être fabriquée pour une large clientèle d'élite, par des constructeurs de haute réputation, tels que Panhard-Levassor, Lorraine-Dietrich, de Dion-Bouton, Delahaye, Delage, et bien d'autres encore.

Le Salon a permis de constater que les moteurs fonctionnent actuellement avec de plus grandes vitesses et de plus hauts rapports de compression. Pour cela, il a fallu placer les soupapes dans une culasse démontable, alléger les pièces mobiles et surtout les pistons, par l'emploi d'alliages d'aluminium, perfectionner l'équilibrage des masses en mouvement, améliorer le réglage des distributions, etc.

La grande majorité des moteurs sont à 4 cylindres, et quelques-uns à 6 cylindres ; les autres nombres sont à peine employés. Un quart des moteurs ont de 1½ à 2 litres de cylindrée totale, et un autre quart de 2 à 3 litres ; un petit nombre seulement ont plus que 3 litres de cylindrée. Les quatre vitesses sont également de règle sur les trois quarts des châssis ; les voiturettes n'ont que trois vitesses.

La formule du bloc-moteur est généralement adoptée ; très souvent, le bloc est fixé en trois points et porte les pédales, ainsi que les leviers, pour laisser au châssis toute facilité pour se déformer.

Le freinage sur les quatre roues se développe rapidement, et s'imposera bientôt sur toutes les voitures de 10 chevaux et davantage, en raison des vitesses élevées qui sont usuelles aujourd'hui. Pour les châssis lourds, les forces du conducteur étant limitées, on les combine avec des servo-freins. Signalons aussi, parmi les éléments de confort que réclament aujourd'hui les automobilistes, un gonfleur de pneumatiques actionné par le moteur.

LE CIMENT FONDU.

Le ciment fondu est considéré comme devant apporter des modifications importantes aux constructions civiles et aux travaux publics. En France, où il a été fabriqué industriellement pour la première fois, il a reçu, depuis peu, d'intéressantes applications. Le ciment fondu est un produit obtenu au four à cuve ou au four électrique, et dont la composition moyenne est la suivante :

SiO_2, 10 à 12% ; Al_2O_3, 40 à 45% ; CaO, 35 à 40% ; Fe_2O_3, 10 à 15%. Son indice d'hydraulicité est supérieur à 1,25.

Les principales propriétés du ciment fondu sont la rapidité de la prise et la grande résistance du béton quelques heures après le gâchage. On peut

décintrer un ouvrage en béton de ciment fondu le lendemain de la mise en place du béton. La résistance au bout de 24 heures est de 29 kgs. par centimètre carré à la traction, et de 352 kgs. à la compression. Cette résistance étant bien supérieure à celle du béton ordinaire, on peut établir les structures plus légères, et par suite donner une plus grande portée aux ouvrages. On envisage la construction de voûtes de plusieurs centaines de mètres d'ouverture.

On a proposé également l'emploi de ce ciment pour construire des ponts en béton armé de la même manière que des ponts métalliques. On moulerait à l'avance des éléments de treillis, et on les réunirait par des joints en ciment fondu, faisant prise en quelques heures. La construction pourrait ainsi être très rapide.

Dès maintenant le ciment fondu a reçu diverses applications intéressantes. On l'a employé pour construire le plancher tronconique du théâtre de Lyon. On utilisait un coffrage radial sur lequel on moulait un secteur étroit de la construction, et qu'on déplaçait presque aussitôt pour mouler le secteur voisin, et ainsi de suite. On a fait ainsi l'économie d'un coffrage complet.

Les travaux de réfection du pavage en bois de Paris, l'été dernier, ont été accélérés par l'emploi du ciment fondu. On établissait la forme un jour, et l'on pouvait poser les pavés dès le lendemain matin.

Une excellente expérience du ciment fondu a été obtenue pendant la guerre, où il a été employé pour construire des plateformes d'artillerie. Avec le ciment Portland, il aurait fallu 6 semaines de prise, et avec le ciment fondu 3 jours suffisaient. On a pu avec ce produit construire des abris de mitrailleuses blindés jusqu'en première ligne.

Un pont en béton armé construit à Lausanne (Suisse) a pu recevoir des tracteurs de 12 tonnes 48 heures après la coulée du tablier en béton de ciment fondu.

Le ciment fondu est fabriqué maintenant d'une façon courante, et son emploi est prévu pour divers travaux importants.

NOTES ON BOOKS.

THROUGH FORMOSA: AN ACCOUNT OF JAPAN'S ISLAND COLONY. By Owen Rutter. London: T. Fisher Unwin, Ltd. 15s. net.

Formosa is well off the beaten track of tourists, and apparently little encouragement is given by the Japanese Government to visit the island; but by a stroke of good luck Major and Mrs. Rutter were enabled to see the country under the most favourable auspices, and as a result we have this book which gives an account of its history, its natural resources, and its native people. It also shows "how in thirty years the Japanese have succeeded, marvellously succeeded, in developing economically what was, when they first took possession of it, little more than a wilderness; and . . . how they have failed, for all their good intentions, in their attempt to settle and administer the native tribes, made intractable by centuries of tyranny and oppression."

Major Rutter modestly states in his preface that his work makes no profession of being a standard work on Formosa: it is written by a passer-by, "who does not profess to have an intimate and exhaustive knowledge of the country such as can be attained only after many years' residence." He has, however, spent a long time in the Far East, and as readers of the *Journal* will know from the admirable paper on "British North Borneo," which he read before the Society last December, and from his book on the same subject which was noticed in these columns about a year ago, he is a keen observer with a wide experience of administration among the Bornean tribes. He was able, therefore, to collect as much information in a short trip as an untrained visitor would amass in many months.

The Japanese, Major Rutter assures us, have met with extraordinary success in every commercial, industrial, economic and scientific enterprise they have undertaken in Formosa. Take the sugar industry, for example. The land under sugar-cane cultivation is now about 300,000 acres, while the annual export of sugar is 250,000 tons, or ten times the amount exported when the Japanese took over the island. Camphor, again (one of the most important products of Formosa) has been greatly improved in quality, and the monopoly in it brings in to the Government no less than £800,000 per annum. Salt, opium, tobacco and alcoholic liquors are also flourishing industries; and some idea of what Formosa trade has gained under Japanese rule may be gathered from the fact that the total of the island's imports and exports has risen steadily from £3,124,696 in 1897 to £27,695,929 in 1922.

But if Japan has succeeded on this side of her work she has failed lamentably in the question of the settlement of the native population. Seven thousand square miles of Formosa, exceedingly rich in camphor forests and probably also in minerals, still remain inaccessible to her. The Japanese are defied by 100,000 pagans, "and inside the electrified barbed-wire entanglement with which they have surrounded these children of the forest they can only venture with their lives in their hands." Major Rutter believes that this failure is due to lack of sympathy and of experience. Before they came to Formosa the Japanese had done no colonising; they still look upon the "savages" as a nuisance and an obstacle, and they have no idea of making friends with them. From certain characteristics which the natives of Formosa share with those of Borneo, Major Rutter believes that the methods which have civilised the British colony would be not less successful with the Japanese.

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FRIDAY, DECEMBER 28, 1923.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2).

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 2nd, at 3 p.m. (Mann Juvenile Lecture.) DR. WILLIAM ARTHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology, "Fire and Explosions." (Lecture I.) The lecture will be fully illustrated with experiments.

Special tickets are required for this course and for the Mann Juvenile Lecture by MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, entitled "Among the Selkirk Mountains of Canada (with ice-axe and camera)," to be delivered on Wednesday, January 16th, at 3 p.m. A few tickets for both courses are still left, and these will be issued to Fellows who apply for them at once.

COMPETITION OF INDUSTRIAL DESIGNS.

Particulars of the Competition of Industrial Designs to be held at the Victoria and Albert Museum in June, 1924, can now be obtained on application to the Secretary, Royal Society of Arts. Over £1,000 will be offered in Travelling Scholarships and Money Prizes in the various sections, and the Society's Diploma will be conferred on any candidate whose work reaches a very high standard of artistic ability and shows practical knowledge of the materials and processes of his trade.

PROCEEDINGS OF THE SOCIETY.

FIFTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 5TH, 1923.

PROFESSOR C. A. SEWARD, Sc.D., F.R.S., Pres.G.S., F.L.S., Professor of Botany in the University of Cambridge, in the Chair.

THE CHAIRMAN said that it was his great privilege to introduce to the Society the Director of Kew, who would speak about the many activities of the Royal Gardens. Dr. Hill had not presided for many years over the destinies of Kew as Director, but he had been associated with the Gardens for a long time past in another capacity. Before he went to Kew he was at Cambridge, and there the speaker had had the opportunity of being with him in the same Departments of that University. He left a School mostly concerned with pure science for an institution which was concerned with both pure and applied science—with pure science to the greater degree, although, of course, it was difficult to draw the line between the two. He had pleasure in calling upon Dr. Hill to read his paper.

The paper read was:—

THE WORK OF THE ROYAL BOTANIC GARDENS, KEW.

By ARTHUR WILLIAM HILL, M.A., Sc.D., F.R.S., F.L.S.,

Director, Royal Botanic Gardens, Kew.

Before attempting to give you some account of the work of the Royal Botanic Gardens, Kew, I feel it is essential to a proper understanding of the functions of Kew to consider for a few minutes the early history of the Gardens, how they came into being, and how their development as the Headquarters of Botanical Enterprise for the British Empire gradually materialised.

As with so many of our National Institutions, Kew, as we know it to-day, was not evolved in any deliberate manner, or as the result of some carefully conceived plan in the brain of any far-seeing Empire builder. Its origin was due to the interest in horticulture of that eminent lady, Princess Augusta of Saxe-Gotha, widow of Frederick, Prince of Wales, who in 1760, under the guidance of the Earl of Bute, started a Botanic Garden of some nine acres in the vicinity of Kew House. Frederick himself would appear to have been interested in gardening pursuits, for after his acquisition of Kew House on a long lease from the Capel family in 1730, he commenced a fresh arrangement of the pleasure grounds, and made additional plantations under the direction of the celebrated Kent.

It was after Frederick's death in 1751 that Princess Augusta gave to Kew Gardens

the definitely scientific character they have ever since maintained.

The date 1760 may be accepted as the commencement of the Botanic Garden, as it was towards the close of the year 1759 that William Aiton, who had been a pupil of the famous Philip Miller at the Chelsea Physic Garden, was engaged by the Dowager Princess of Wales to establish at Kew a Botanic, or, as it was then termed, a Physic garden.

Princess Augusta died in 1772, but during the last twelve years of her life she was assisted in her botanical pursuits by John Stuart, third Earl of Bute, who was keenly interested in botany. This science, apart from his brief political career, was the principal occupation of his life, and his interest in botany has scarcely received the appreciation it deserved. It should, however, be borne in grateful remembrance that he took a very active part in developing the botanical side of Kew. Some of the trees planted under his direction still exist, notably the fine Maidenhair tree (*Ginkgo*) and a *Diospyros* near the site of the Temple of the Sun, which among others were probably brought from the garden of the Duke of Argyle near Hounslow in 1762.

That the collection of plants at Kew in these early days was a remarkable one is shown by Sir John Hill's *Hortus Kewensis*, published in the year 1758, which was an octavo volume of 458 pages forming a catalogue of the plants cultivated in the garden of Her Royal Highness the Dowager Princess of Wales at Kew. This catalogue enumerates 3,400 species, 488 being hardy trees and shrubs and 200 tender shrubby plants; while in 1770 Sir John speaks of Kew as "that garden where every tree that has been seen in Europe is at hand."

After the death of Princess Augusta, George III. purchased the freehold of Kew House and grounds from the Dowager Countess of Essex, and amalgamated them with the gardens of Richmond Palace, which had been the residence of George II. and Queen Caroline. Love Lane, which separated the two properties, was the old roadway from Richmond to Brentford Ferry, and the present Kew Road is its successor. The original Love Lane is still preserved in the Holly Walk in the Gardens, but though George III. was empowered to close the lane in 1765, it seems doubtful whether the two Royal Gardens were really united until about the year 1802. Many of the trees still at Kew, in the part which was formerly Richmond Gardens, were planted under the direction of Queen Caroline.

With the acquisition by George III. of the two Royal Gardens and the appointment of Sir Joseph Banks as Botanical Adviser, or in effect "Director" of the Royal Gardens, in place of Lord Bute, the "Golden Age" of Kew may well be said to have commenced.

The King maintained the botanical character of Kew with even greater energy than did his Mother, and supported with keen interest the various botanical activities initiated by Sir Joseph Banks, which have resulted in Kew occupying the position it holds to-day in relation to botanical enterprise throughout the Empire.

To Sir Joseph was due that practice, which has yielded such fruitful results, of sending out collectors to various parts of the British Empire and to other countries, which, after lapsing and being revived by Sir William Hooker, has in recent times been continued by the leading nurserymen and by private enterprise.

In the year 1772, Sir Joseph Banks, being then President of the Royal Society, addressed a memorandum to the King with reference to sending Francis Masson, an under-gardener at Kew, to collect seeds and living plants at the Cape of Good Hope "for the Royal Botanical Garden at Kew."

Masson made remarkably fine collections, and sent home over 400 species of living plants. At least one of his plants, the interesting Cycad *Encephalartos longifolius*, still exists in the Palm House, while among others were *Cineraria cruenta*, the parent of our garden Cinerarias, and the wild Cape Pelargoniums, from which have been evolved our garden "Geraniums." From the long list of Kew Collectors one or two names deserve special mention. Among them, that of David Nelson, who was Assistant Botanist on Captain Cook's third voyage, and subsequently accompanied Captain Bligh on the ill-fated voyage of the "Bounty." The genus *Eucalyptus* was founded by L'Heritier—the French Botanist who came to England 1786-87, and studied the Kew collections—on a species (*E. obliqua*), which was found by Nelson in Tasmania. Then there is Archibald Menzies, who accompanied Captain Vancouver (1791-95), and brought home seeds of the Chilian Monkey Puzzle (*Araucaria imbricata*), which Sir Joseph

Banks planted, some at his own place at Spring Grove, Isleworth, and the others at Kew. It is a pity that Sir Joseph's name is not still commemorated by the retention of the early name "Sir Joseph Banks' Pine," by which it was first known. Menzies also discovered *Sequoia sempervirens*, the Californian Red Wood. I must also refer to Christopher Smith, who went with Bligh on his second successful voyage to convey the Bread fruit to the West Indies, and afterwards collected in India; Peter Good, who was in Calcutta and Australia; George Caley, who was appointed by Sir Joseph as botanical collector in New South Wales; William Ker, who was sent to collect in China; Alan Cunningham, who travelled as a collector for Kew, in Brazil, The Cape and Australia, and David Lockhart, who was the only survivor of the scientific staff of Captain Tuckey's Congo Expedition of 1816. These are some of the most famous of the earliest of the Kew Collectors.

Three of these same men also deserve further mention, namely, William Ker, who in 1812 was appointed Superintendent of the Royal Botanic Garden, Ceylon, founded in 1810; George Caley, who was Superintendent of the Botanic Garden, St. Vincent, from 1816 to 1822—the earliest of our Tropical Gardens founded in 1765—and David Lockhart, who was apparently the first Superintendent of the Botanic Garden in Trinidad, where a Garden was founded in 1817. Thus began that long and valuable connection, which still happily exists, between the Royal Botanic Gardens, Kew, and the daughter Botanic Gardens which have gradually been established in practically every British Colony and Dominion.

A glance at the *Kew Bulletin* appendices giving the List of Staffs of the Botanical Departments at home, in India and the Colonies during the last 35 years, will show that gardeners trained at Kew are at the present time, or have been until quite recently, in places so remote as the Falkland Islands, the Fiji Islands, the Seychelles, Rodriguez, Central Africa, Hong Kong, Port Darwin, Australia, New Zealand, and, in fact, throughout the British Empire.

One of Sir Joseph Banks' schemes was to found a Herbarium and Library at Kew. The present Herbarium and Library occupies the house originally known as Hunter House (the property of Mr. Robert Hunter), which it is believed was purchased for the King in 1818, at the instigation of Sir Joseph Banks, for the purpose to which it is now dedicated. A room on the ground floor was fitted with bookshelves, and no doubt the botanical collections brought home by the Kew Collectors were deposited in the building.

Unfortunately, the King and Sir Joseph both died in 1820, and Kew suffered greatly in consequence. Sir Joseph's Library and Herbarium, including the botanical specimens brought home by the Kew Collectors, were bequeathed to the British Museum, and became the foundation of its Botanical Department, so that Kew, unfortunately, does not now possess the fruits of the labours of her earliest sons.

George IV. at first took a good deal of interest in Kew, and adhered to the plan of adapting Hunter House to its present purpose. He also added considerably to the amenities of the Gardens on the Kew Green side, but in 1823 he sold Hunter House to the Nation. Notwithstanding this, however, William IV., about 1830, granted its use to the Duchess of Cumberland for her life, and, on the Duke's accession to the throne of Hanover, it became generally known as Hanover House. Here the King of Hanover sometimes resided, but after his death in 1851, it remained unoccupied, and in 1852 its use for Herbarium purposes once more commenced, thanks to the action of Sir William Hooker.

The house itself now serves as our Library, while the Herbarium occupies two extensive wings which have been added to the north and to the west of the original house. The Herbarium contains a remarkable series of specimens of dried plants from every part of the world, representing especially the floras of the various parts of the British Empire. Between 3,000,000 and 4,000,000 specimens and comprehensive collections of plant portraits, fruits and seeds, are preserved in the Herbarium, while the Library, which is probably the finest botanical library in existence, contains some 30,000 volumes. The annual additions of pressed specimens to the Herbarium amount to about 30,000 sheets.

The death of Sir Joseph Banks, in 1820, was a serious blow to Kew, and though the activities which he initiated, and which received such warm support from George III., were continued to some extent after his death, there was no real progress in the development of the Gardens, but rather they suffered a steady decline.

George IV. soon abandoned Kew for Windsor and Sir Everard Home appears to have assumed the task of directing the affairs of Kew, and used to meet at the house of Francis Bauer "the eminent men of the day for purposes connected with Botany and other branches of Natural Philosophy."

Francis Bauer, F.R.S., it should be mentioned, was an Austrian who came to England in 1788 and in 1790 was, through Sir Joseph Banks' liberality and with the King's sanction, attached as Draughtsman to the Botanic Garden. He occupied the position for fifty years, until his death in 1840. This most essential post in connection with a Botanical Institution such as Kew has recently been properly recognised by Government, and a Botanical Artist is now one of the established officers on the scientific staff of the Royal Botanic Gardens.

Sir Everard Home died in 1832, two years after the death of George IV., and, though William IV. took a warm interest in Kew, the Gardens and all that Sir Joseph Banks had laboured to achieve, languished, and their scientific importance was so lost sight of that the scientific botanists of the day appear almost entirely to have got out of touch with Kew.

Collecting activities fortunately did not entirely cease, and some valuable additions were made, but the Gardens were still a private establishment. Visitors, however, had free access on certain days, thanks largely to Mr. W. T. Aiton (son of the first Curator, W. Aiton), who was Director-General not only of Kew but of other Royal Pleasure Gardens in addition.

It was after the death of William IV., in 1837, that the position of the Royal Gardens became precarious, and their abandonment was seriously considered, so much so, that the Treasury in January, 1838, appointed a Committee "to inquire into the management, etc., of the Royal Gardens." This committee consisted of Dr. Lindley and two practical gardeners, one of whom was the future Sir Joseph Paxton. Without going into the full details of their inquiry, and narrating all that took place when Dr. Lindley's Report was presented to Parliament in 1840—though he reported in 1838—it will suffice to record that after the discussion in the House of Lords, the charge of Kew was removed from the control of the Board of Green Cloth, and transferred to the Department of Woods and Works on March 11th, 1840.*

On the dissociation of the Department of Woods from the Office of Works, Kew, like the Royal Botanic Gardens, Edinburgh, came under the control of H.M. Office of Works, but though the Edinburgh Gardens are still in the domain of the First Commissioner of H.M. Works, Kew was transferred in 1903 to the care of the Board (now the Ministry) of Agriculture and Fisheries, as far as its general administration is concerned.

When this transfer took place, it was laid down "that the privilege enjoyed by the Foreign Office, Colonial Office and India Office of corresponding directly with the Director will be preserved to those Departments," and I need hardly point out, that from the nature of the work performed at Kew, this very important privilege is highly valued by the Director of Kew.

The outcome of Dr. Lindley's Report was the renaissance of the Royal Gardens, which dates from the year 1841, when, on April 1st, Sir William Hooker, F.R.S., Regius Professor of Botany in the University of Glasgow, was appointed Director of the Botanic Gardens.

In the year 1841, W. T. Aiton resigned his position of Superintendent of the Botanic Garden—a post he had held for fifty years—and John Smith, previously Foreman, was appointed Curator, and was the first Curator of Kew as a Public Establishment.

The continuance of the existence of Kew in these evil days seems to have been due rather to the interest of Her Majesty Queen Victoria, than to the popular agitation that

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*The following is the principal part of Dr. Lindley's Report presented to Parliament in 1840.

"The importance of Botanic Gardens has for centuries been recognised by the governments of civilised states, and at this time there is no European nation without such an establishment except England. The wealthiest and most civilised country in Europe offers the only European example of the want of one of the first proofs of wealth and civilisation. There are many gardens in the British Colonies and Dependencies, as Calcutta, Bombay, Saharunpore, the Mauritius, Sydney and Trinidad, costing many thousands a year; their utility is much diminished by the want of some system under which they can all be regulated and controlled. There is no unity of purpose among them; their objects are unsettled, their powers wasted from not receiving a proper direction; they afford no aid to each other, and, it is to be feared, but little to the countries where they are established; and yet they are capable of conferring very important benefits on commerce, and of conducing essentially to colonial prosperity. . . . A National Botanic Garden would be the centre around which all these lesser establishments should be arranged; they should all be placed under the control of the chief of that garden, acting with him and through him with each other, recording constantly their proceedings, explaining their wants, receiving supplies, and aiding the mother country in everything useful in the vegetable kingdom; medicine, commerce, agriculture, horticulture, and many branches of manufacture would derive considerable advantage from the establishment of such a system. . . . From a garden of this kind Government could always obtain authentic and official information upon points connected with the establishment of new colonies."

its proposed abandonment aroused. The following extract from a letter to John Smith by Mr. Aylmer Bourke Lambert, a private gentleman keenly interested in botany, who seems to have succeeded to the role of Sir Joseph Banks in the affairs of Kew, is of interest in showing the part played by the Sovereign in the preservation of Kew.

March 9th, 1840. "You will not be a little surprised, and I think not less grateful when I tell you that your letter that you wrote me giving particulars of the origin of Kew Gardens, and the interest taken by the Princess of Saxe-Gotha, that said letter went to the throne, and (was) read by Her Majesty and Prince Albert, they were much interested in it. There is no doubt that was the reason Lord Ilchester came to Kew, as he is one of Her Majesty's household."

Sir William's charge, when he assumed office, comprised only 15 acres, yet his appointment inaugurated that new era in the history of Kew, which, though perhaps in some directions not so eventful as in the days of Sir Joseph Banks, has been a period of uninterrupted progress and notable achievement.

These, then, were the traditions of Kew, and such were the labours of other men into which Sir William Hooker, in 1841, was called upon to enter. In that year, Kew was not, alas, the inspiring place created by Sir Joseph Banks, but a moribund and decadent institution waiting to be restored to its former eminence, a task for which Sir William was peculiarly fitted. It is no doubt his son and successor in office, Sir Joseph Hooker, who is generally thought of as the Director who re-established the prestige of Kew and succeeded in making it the centre of botanical enterprise for the Empire, but it must not be forgotten that practically every one of the proposals and schemes for the development of the work of Kew on the lines which are still followed, were conceived with remarkable foresight and set in motion by Sir William Hooker.

In 1843 Sir William Hooker, as I have stated, reverted to the plan initiated by Sir Joseph Banks, of sending collectors to distant countries for the purpose of transmitting plants and seeds to the Royal Gardens. Among Sir William's Collectors should be mentioned W. Purdie, who was sent to New Granada; G. Mann, who went to the Cameroons, Gaboon River and Fernando Po; W. B. Baikie and C. Barter, who went to the Niger; John (later Sir John) Kirk, to the Zambesi with Livingstone; Sir Joseph Hooker to the Himalaya; Edmonstone, followed by B. C. Seemann, to Western and Arctic America in H.M.S. Herald, and the latter to the Fiji Islands with Col. Smythe's mission, and also R. Spruce who was sent to Ecuador for Cinchona seeds.

It would be a long story were I to attempt to give in detail the history of the many activities of Kew, even with regard to India and our overseas Dominions and Colonies during the Directorships of the two Hookers, of Sir William Thiselton-Dyer and of Sir David Prain; for the Director of Kew is also Botanical Adviser to the Secretary of State for the Colonies, and is consulted on Indian botanical matters by the Secretary of State for India. Thus the shelves of the Director's office are filled with folios dealing with questions concerning the introduction of useful plants to our Colonies and India from other regions, and with every sort of enquiry as to the world's economic products so far as they relate to the vegetable kingdom.

The work of the Royal Botanic Gardens, Kew, is divided up into four main divisions, only one of which, however, is generally known about and appreciated by the people of this country. This, I need hardly say, is the garden proper. To most people the name Kew Gardens, or as they should properly be called, the Royal Botanic Gardens, Kew, represents a beautiful garden of herbaceous plants, trees and shrubs, and many greenhouses, some of which they find uncomfortably hot. To a select few, who, one is glad to say, are ever an increasing number, the Gardens are recognised as the place where the attempt is made to cultivate every variety of plant "that is pleasant to the sight and good for food," under the best conditions that Kew can provide, and they, together with those botanists who are also lovers of plants, fully appreciate the scientific order of the collections. These have been so skilfully arranged, thanks largely to the keen instinct for landscape effect possessed by Sir William Thiselton-Dyer and by the Curators of the Gardens, that the general public are scarcely aware that the garden lay out is governed by any scientific principles at all.

One is tempted to believe that among our many student visitors there are some

who have realised that the "Tree of Knowledge" also is to be found at Kew.

The next department which commands a fair share of public interest, and also, one hopes, serves as a means of liberal education, is that of the Museums.

Four Museum buildings now house the varied and extensive economic collections, which comprise examples of the economic products of the plants of the world. The Museum collections, though brought together with the definite purpose of illustrating the uses to which plants may be put, are really complementary and ancillary to the collections in the Herbarium and in the Garden, and one collection without the other would lose very much of its importance and value. The housing of the collections in four separate buildings, is an unfortunate arrangement as far as economical working of the Department is concerned, and also somewhat unsatisfactory since three of the buildings have been adapted to serve their present purpose and are not as well suited for the exhibition of specimens as they might be.

The original museum collection, which was the first of its kind brought together for the purpose of exhibiting in systematic order the economic products derived from plants, was due to the foresight of Sir William Hooker. In 1847, owing to Sir William's representations, the fruit storehouse belonging to the Royal Family, now Museum No. II., was, by Her Majesty's command, added to the Botanic Garden and Sir William's own private collection, which he presented to the Nation, formed the nucleus around which our present extensive collections have been built up.

The objects exhibited could not be shown either by the living plants in the Garden or by the specimens preserved in the Herbarium, and the value of these collections has become increasingly evident in the course of years, so that now practically every vegetable product from any part of the globe can be accurately determined.

As soon as the establishment and aim of the Museum was generally made known, contributions poured in from all quarters of the world, and the original building became so crowded that application had to be made to Parliament for a new building for the proper accommodation of the specimens.

In 1857, to meet this need, the present No. 1 Museum was opened. Here the economic products derived from the Dicotyledonous plants (including such well-known objects as cocoa, coffee, cinchona, rubber, tea, etc.), are displayed, while the products derived from the Monocotyledons, such as palms, bamboos, grasses, the various food grains and articles, such as mats, hats, vegetable ivory, etc., are exhibited in the original museum, now called Museum No. II. Thus it may now, I believe, be said with full truth that it is almost impossible to point out any Colonial product, however insignificant, which is not adequately represented in the Kew Museums.

No. III Museum, the home of Tropical Timbers in particular, was formerly the Orangery of the original Royal Gardens; while No. IV. Museum, our most recent acquisition, which contains a remarkable collection of British-grown timber, and the articles made therefrom, as well as a complete series of the fungus and insect pests to which trees are subject in this country, has been housed in Cambridge Cottage. This building was formerly the private residence of His Royal Highness, the late Duke of Cambridge, and was after his death graciously made over to Kew by the Crown, and opened to the public in 1910.

Three of our Museum Buildings, as I have mentioned, are none too well suited for their purpose, since they were not built for the display of museum specimens, still, they serve their function very fairly well. No. I. Museum was enlarged in the year 1881, and both it and No. II., which is the least suitable for a museum, are now inconveniently crowded. It is to be hoped that before long a further enlargement of No. I. Museum may be sanctioned on such a scale that not only the crowded out products derived from the Dicotyledonous plants can be included, but also the Monocotyledon exhibits now displayed in No. II. Museum. If this should ever be sanctioned, then the whole range of vegetable products, exclusive of the timbers of the world, could be studied under one roof, in proper systematic sequence.

What, it may be asked, is the purpose of these collections, and in what way are they connected with the work of Kew? Their chief object is to show the practical applications of botanical science, and to enable students and those engaged in commercial pursuits both at home and from overseas, to appreciate the general relations of the vegetable world to man, and in

particular to exhibit the vast resources of the Empire. We learn from them the sources of the innumerable products furnished by plants for our use and convenience, whether as articles of food, of construction and application in the arts, of medicine or curiosity. They also show us the points where we need further information, more especially as to the origin of many valuable timbers, fibres and drugs.

In short, not only do these collections tell us how much we have already discovered, but also how little we still know of the extent to which herbs, shrubs and trees contribute to our necessities, comforts and our numberless requirements.

Closely associated with the Museums, as it is also with the garden proper and the work of the Herbarium, the Jodrell Laboratory must now be mentioned. Here, thanks to the munificence of Mr. T. J. Phillips Jodrell, who built and equipped the Laboratory at his own expense in 1876, we have a department where work can be undertaken to determine the structure, functions and properties of obscure vegetable products, and it is seldom that it is not possible by means of careful research, to solve the problems which are constantly being presented to us by our correspondents both at home and abroad. Without the wealth of material in the Museums and the Herbarium for comparison and examination, the many valuable results which have been achieved in this laboratory would not have been possible.

The Laboratory is also fitted for physiological and mycological investigations, and some famous researches by distinguished botanists have been carried out within its walls. Research students are welcomed here, and are able to study, as nowhere else, the problems presented by the vegetation of the globe illustrated, as it is, by the collections of living and preserved plants in the Royal Botanic Gardens.

The North Gallery, built and presented by Miss Marianne North, in 1885, is also an appanage of the Museums, and, as is well-known, in this remarkable botanical picture gallery plants from all over the world may be seen painted in oils by her master hand. The pictures are renowned for their botanical accuracy as well as for their artistic skill, and these qualities render them of infinite value in a scientific establishment like Kew where an attempt is made to grow, portray, preserve and study as fully as possible the wonders of the vegetable kingdon.

A smaller collection of pictures by Miss M. H. Mason, of South African plants, in Museum No. IV., may also be referred to here, since they enable us to appreciate very clearly the special characteristics of the vegetation of South Africa.

This brings me to the fourth department, the Herbarium. The present Herbarium collections, as I have stated, owe their origin to Sir William Hooker, since those earlier and famous collections made by Sir Joseph Banks and the Kew Collectors, are now at South Kensington.

When Sir William came to Kew, he brought with him his own large collection of dried plants, and in 1854 this was greatly augmented by the collections of the distinguished botanist, Mr. George Bentham, who presented his fine private Herbarium and Library to the Nation. This nucleus has been continually added to by official contributions, by exchanges and by the judicious expenditure of our small annual parliamentary grant voted for the purpose, so that now the Kew Herbarium contains between three and four million specimens.

In the Herbarium, which is the largest and most completely organised in the world, in addition to the collection of dried specimens, we possess a magnificent collection of coloured botanical drawings of plants, so that not only can a large number of the plants of the globe be studied in the living condition, and as pressed specimens, but they can be examined as delineated by botanical artists, both as they have flowered at home, and also in many cases (Miss North's pictures) as they grow and flower in their native countries.

Such botanical studies are of very great assistance to the work performed at Kew in connection with the Floras of the different parts of the world.

The work carried out in the Herbarium is one of the most important of the functions of Kew. What exactly that work is may be gathered from a perusal of the pages of the *Kew Bulletin* for the year 1905, compiled by Sir William Thiselton-Dyer. In addition to the attempt that is being made to complete a botanical survey of the Empire, detailed researches are being undertaken in connection with the floras of the world, and particular attention is always being paid to the determination of plants which may prove to be of economic

importance, whether as food or for use in the arts, and which might be introduced with advantage to one or other of our overseas possessions.

Unless a plant, which may possess definite economic possibilities, has been identified botanically, it is quite useless to attempt its introduction to cultivation without incurring the grave risk of bringing in a worthless plant. The more we get to know about plants, and the more we discover how considerable a range of variation they exhibit, both as regards form and in their constitution, the more we understand the importance of arriving at an exact determination of the particular species or of some special varietal form which it may be desirable to introduce in order that it may be a commercial success.

Had it been appreciated earlier that species show fundamental physiological variations, which are often only rendered apparent by experiment in the laboratory, as well as the more easily discernible morphological variations, much labour and money might have been saved.

I may instance two examples which affect the British Empire, with both of which Kew has been intimately concerned.

In the one case, that of Camphor, the product derived from *Cinnamomum Camphora*, Nees, native of Formosa and Japan, Kew must plead ignorance. In the other, that of Para Rubber *Hevea brasiliensis*, Muell. Arg. the blame must be attached to the rubber growers. They failed to appreciate the fact that science could help them in selecting the best trees to cultivate in their plantations and thought that from the seeds of any tree of *Hevea brasiliensis* they would obtain the plants they required. Scientific research, however, has shown that the percentage of latex yielded by individual trees varies very greatly in amount, for while some trees yield only 2% of latex, others yield as much as 40%. Had the warning note which was sounded by Kew and by others been regarded, which was, that seed from untested trees should not be sown promiscuously, rubber plantations to-day might have been furnished with a larger proportion of the best latex-yielding trees than is now the case.

With regard to Camphor, it is only recently that it has become known in the West that there are two varietal forms of the Camphor tree, both so alike in their external botanical characters that they can hardly be separated. One of these yields the valuable solid camphor on distillation, the other camphor oil, a product of little commercial use. Since Camphor can be cultivated in several British Colonies, seed was obtained through Kew for growing in Mauritius, the West Indies and other Colonies. Unhappily, however, the seed which was procured emanated from the oil-producing trees, which were well-known to the senders, so that, except in a few isolated cases, there are scarcely any true Camphor trees in the British Colonies.

Problems of this nature abound in the realms of economic botany, as for instance, the exact determination of the best type of Willow for making cricket bats which was worked out at Kew, or in the domain of textiles such as the finding of the best strains of Cotton, New Zealand flax, Sisal or other fibre plants, which from time to time are temptingly brought to the notice of the prospective investor.

Several forms are known, both of Agave and Ananas, as members of this society are well aware, which are of little value for fibre production, and such are clearly recognisable by their botanical characters. It is in questions such as these that a botanical institution like Kew, with all its resources, can afford so much assistance to industry if only those concerned in commerce will seek our aid.

The principal work of the Kew Herbarium, however, is, as I have said, the systematic investigation and description of the floras of the world, and in particular, those of the British Empire. Owing to our close connection with India and the Colonies, vast collections of plants have poured in from every quarter, and it is the work of the Herbarium staff to name, preserve and arrange them so that they may be available for reference and study.

It is a matter of regret and a serious handicap to the full measure of our usefulness, that, despite additions to our staff, the influx of new material has ever been greater than could be absorbed, even with the most unremitting energy.

Both the Home and Colonial Governments and the Government of India have been generous in affording financial assistance to enable us to tell them of the wealth and potentialities of their floras. But you will, I feel sure, agree that far more help is required if Kew is to maintain its proud position as the premier botanical

establishment of the world, when I tell you that in our stores we still have accumulations of preserved material, largely from the Empire, amounting to some 200,000 specimens. This position, which it must be our earnest endavour to uphold, when British interests are so immense both in the domains of pure and applied botany, can perhaps best be maintained by the generosity of private benefactors, and should there by any happy chance be such an one among my audience, I can assure him that assistance of this nature would benefit humanity at large to no small degree. I may mention here that the great American Institution, the New York Botanical Garden at Bronx Park, has received very large sums in the way of private benefactions, the number and magnitude of which fill me with envy.

Science never likes to beg, but should there be anyone anxious to help forward a great task, I would commend to their notice the work which, thanks to the generosity of Charles Darwin, has been undertaken at Kew. I allude to the *Index Kewensis*, that great register of all the species of plants, giving their habitats and references to the place and date of publication, of which five supplements have now been published in addition to the four original volumes produced at Darwin's expense. I may mention here that we estimate that the VIth quinquennial supplement of the *Index* will contain some 35,000 entries of new species, while in the Vth supplement, published in 1921, 37,000 new names were registered. These figures, together with those I have given of the number of our herbarium specimens, will perhaps indicate something of the magnitude of the work that is being undertaken in the Herbarium, and in particular of the heavy tax on our resources that the preparation of the *Index* entails; a work that is indispensable to botanists and horticulturists throughout the world.

I must not omit to mention, however, that Kew does receive some valuable help from the Bentham Trustees, who administer the legacy of that illustrious botanist, Mr. George Bentham, who left a sum of money for the purchase of books and specimens for Kew.

What, however, has been achieved at the Herbarium in addition to the labours I have already sketched? I can best answer by pointing to the long rows of the Colonial and Indian floras, and such ancillary works as "The Dictionary of Economic Products of India," and "The Useful Plants of Nigeria," all of which have been prepared at Kew.

The proposal that a series of Colonial floras should be compiled at Kew was made by Sir William Hooker as long ago as 1863, and it is of interest to compare his proposals which were made public in the *Annals of Botany* for 1902 (p. lxxxiii) with the results that have so far been accomplished.*

*"The Life of Sir William Jackson Hooker," by Sir Joseph Dalton Hooker, in the *Annals of Botany*, Vol. XVI., Nl. LXIV., Dec., 1902, which gives a vivid account of Sir William Hooker's work at Kew. *See also Kew Bulletin*, 1905, p. 20.

COLONIAL AND INDIAN FLORAS.

Sir W. Hooker's proposals.	Volumes.	Present position.	Volumes.
1. Australian Colonies including Tasmania.	8.	Flora Australiensis.	7.
2. South African Colonies.	10.	Flora Capensis.	10.
3. British North America, Pacific to Atlantic.	2.	(Not prepared).	
4. West Indian Colonies.	2.	Flora of the British West Indian Islands. (A new work is now needed.)	1.
5. New Zealand.	1.	Handbook of the New Zealand Flora.	1.
6. Ceylon.	3.	Handbook of the Flora of Ceylon.	5 and 1 quarto volume of plates.
7. Hongkong.	1.	Flora Hongkongensis.	1.
8. Mauritius and the Seychelles.	1.	Flora of Mauritius and the Seychelles. (A new work is now needed.)	1.
9. British Guiana.	2.	(Not yet commenced).	
10. Honduras.	1.	(Not yet commenced).	
11. West African Colonies.	2.	Flora of Tropical Africa.	2.
12. British India.	10.	Flora of British India.	7.

In addition to these the following Floras have already appeared, or are in course of preparation, and have been prepared wholly or mainly at Kew:—

1. Materials for the Flora of the Malay Peninsula.	6 volumes.
2. Flora of the Malay Peninsula. (in preparation, 2 vols. issued)	5 volumes.
3. Flora of the Upper Gangetic Plain. (1 volume to complete)	3 volumes.
4. Flora of the Presidency of Madras.	5 parts (under continuation).
5. Flora of the Presidency of Bombay.	2 volumes.
6. Index Florae Sinensis.	3 volumes.
7. The Commercial Products of India.	1 volume.
8. The Useful Plants of Nigeria.	4 parts.
9. The Flora of West Africa (in preparation).	
10. Floras of Bermuda, St. Helena, Ascension, Tristan da Cunha were published in the Scientific results of the Challenger Expedition.	
11 Sketch of the Forestry of West Africa (Moloney)	1 volume.

A proposal to prepare a Flora of Trinidad has been under consideration for some time, but it has not yet been found possible to undertake this very desirable piece of work.

In place of Sir William Hooker's proposed "Flora of the West African Colonies," "The Flora of Tropical Africa" has resulted, and is now nearly complete, comprising eleven volumes. So greatly has our knowledge extended, of the flora of our West African Colonies, that it has been found necessary to ask the Governments of our four West African Colonies, The Gambia, Sierra Leone, The Gold Coast and Nigeria, to subsidise the preparation of a "Flora of West Africa." This proposal, I am happy to say, has received the approval of the Secretary of State for the Colonies, and of the Colonial Governments, and work was commenced in September last on this new undertaking. When this new compact Flora is published, it will, I believe, be possible, not only for the botanist but for all interested in the vegetation and vast botanical resources of West Africa, to determine the plants they meet with, and learn something of their economic possibilities.

The floras of Trinidad, and the splendid vegetation of British Guiana and British Honduras, and, strange as it may seem, the flora of Canada, still await attention; and, as might be expected, the earlier volumes of the Flora Capensis published between 1859 and 1865, require to be almost entirely re-written, so greatly has our knowledge grown of the vegetation of South Africa in recent years. Similar remarks apply to the Floras of Mauritius and of the West Indies.

Thus, though much has been accomplished, even more remains to be done, and, as in every other branch of science, it is not possible to foresee any termination to our activities, but rather each accession of new knowledge opens up long vistas and enlarged spheres of useful and necessary work.

Not only do we deal in the Herbarium with the flowering plants and ferns, but with the mosses, lichens, seaweeds and fungi of the world as well, and such matters as the serious Panama disease of bananas, the coffee leaf disease (*Hemileia*), which devastated the flourishing coffee plantations in Ceylon, and other noxious or less harmful plant diseases from time to time demand investigation on the part of our scientific assistants.

Every post brings some enquiry of interest, and frequently one which necessitates careful and laborious research, or, on the other hand, it may open out some possibility of utilising a new economic product for the benefit of one of our distant Colonies.

We are prepared to report upon and obtain advice with regard to new vegetable industries, though it may relate to so small a matter as the supply of West African palm kernels for carving into coat buttons, or as to the value of a pithy stem as a material for a razor strop, on which—before the days of safety razors, I need hardly say—Kew reported to a West Indian Government, or even, quite recently, as to the botanical identity of the wood of a walking stick, about which its owner, as we discovered later, had made a bet!

I must, however, return to the garden side of Kew in order to illustrate more fully our close connection with the Colonies and India.

It was through Kew, as I think it is now well-known, that the Para rubber industry of the East was founded, and that the cultivation of Cinchona in India, Ceylon and Jamaica came about. This latter enterprise had been urged by Sir Joseph Banks more than half a century before.

These two remarkable introductions of South American economic plants were made

possible through the assistance given by Kew to the two enterprises, for the seeds of both plants were despatched to Kew from their native countries (*Hevea* in 1876, *Cinchona* in 1861), and the young plants which were raised in our greenhouses were despatched in Wardian cases to the East, where they now flourish. In the one case, the successful achievement has brought very large financial returns, and in the other, the possibility of sound health in the tropics to a vast number of people.

I might give an account of many other projects that Kew has undertaken did time permit, such as the introduction of the very useful Teff grass from Abyssinia to South Africa; the annual sending of Mahogany seeds from the West Indies to India, and the building up there of Mahogany forests; the advice and help which Kew has afforded to the experiment in afforestating the barren tree-less Falkland Islands, and the sending of seeds and cases of useful plants to the Islands of Ascension and St. Helena with the result that Ascension is now furnished with useful thickets of trees. Kew has also rendered assistance which has been of value in setting up the lucrative Onion-growing enterprise in Antigua, and in connection with the making of paper from the "Ginger Lily," *Hedychium coronarium*. Then, again, reference must be made to the sending of Cacao plants to the Gold Coast since the success of the Cocoa plantations there is largely due to the assistance and advice afforded by the Royal Botanic Gardens.

Interesting stories about many other economic plants, valuable for their fibre, for paper making, spices or drugs, or for their food value, with which Kew has been intimately concerned, could also be related. I must, however, pass on to the consideration of a further sphere of usefulness to which we attach great importance, and which has been attended with far-reaching results; that is, the work of completing the botanical and horticultural training of the young men who come to Kew for a period of two or three years as Student Gardeners.

In this respect Kew may be regarded as a University of Horticulture, and perhaps more particularly of Tropical Horticulture, since so many of her sons go out to every part of the Empire to carry on the science and practice of Horticulture in the Botanic Gardens and Agricultural Stations in the Tropics.

That this should be the case is only natural since in no other Institution in this country can so much be learned about the vegetation of the Tropics, and the proper method of cultivation of tropical economic and other plants. Men trained in botany and agriculture in our Universities are no doubt well equipped in the scientific principles underlying their subject, but they are perforce sadly handicapped, owing to their lack of practical knowledge of the plants which they will meet with in our Colonies in connection with their work.

With the growing and legitimate demand for men who have passed through a University on the part of the Colonial Governments, the men trained at Kew are often placed in a difficult and unfavourable position, but I venture to say that the best of our students will be found, in the long run, with their practical knowledge added to the theoretical instruction provided for them at Kew, to be able to hold their own in comparison with the men who have had better opportunities in the way of a course at a University or at an Agricultural College

Neither class of men, I would submit, are entirely satisfactory for sending out straight from home to some distant Colony where they will be confronted with problems with which they are, to a great extent, unfamiliar, but now that the Imperial College of Tropical Agriculture has been so successfully established in Trinidad, I am convinced that at last we have the opportunity of completing the education necessary both for the University candidate and for the man trained at Kew, so that they may become efficient scientific officers qualified to serve in whichever of our Tropical Colonies or Dominions their services may be required.

I have recently had occasion to bring this aspect of the training of scientific officers for colonial posts to the notice of the Secretary of State for the Colonies, and I hope that my proposals may meet with His Grace's approval, and that they may also be favourably considered by the Governors and Directors of Agriculture of our Colonies.

The important part that Kew has played in the past, and I am glad to say is still maintaining, in sending out her sons to distant lands in Government service, is, as I have indicated earlier, in direct continuity with the policy initiated by Sir Joseph Banks over a century ago, when Kew men were sent to take charge of the Botanic Gardens in Ceylon, St. Vincent and Trinidad.

The connection between the Royal Botanic Gardens, Kew, and the many daughter Botanic Gardens and Stations overseas—which have now very generally become the centres of flourishing Agricultural Departments—has been of inestimable benefit both to the Home and to the Colonial Institutions, and has served to weld that link of union and mutual help and sympathy which it is so essential to preserve.

Before leaving this portion of my subject, I may perhaps be allowed to mention that at the present time among the higher posts held by Kew men in the Colonies, one of our former student gardeners is Director of Agriculture in the Gambia and another is Commissioner of Lands and Forests, Sierra Leone. Another is Superintendent of the Botanic and Forestry Department, Hongkong, and the Economic Botanist, Trinidad, also received his early training at Kew, while the Superintendents and Curators of almost every one of our Tropical Agricultural Stations and Botanic Gardens have passed through Kew. In the United States of America it is of interest to note that Kew-trained men are held in high esteem. One is now Assistant Director of the famous Arnold Arboretum, and several others hold important horticultural appointments in that country. The value of the Kew training is further emphasised by the fact that several of our Scientific Assistants received their early training in the Gardens, including the present Assistant Director, who, before returning to Kew last year, held important posts in the Gold Coast as Assistant and Deputy Conservator of Forests and in Singapore as Assistant Director of the Botanic Gardens.

I cannot close this account of the work of the Royal Botanic Gardens without a brief reference to the building where all the various activities are centred, namely, the Director's Office; a small and unpretentious building of great interest from its historical associations. I believe the Director of Kew has been compared to a spider at the centre of his web, and the comparison is not altogether inept, since he has to keep in intimate touch with all the threads of the work in progress in each of the separate departments, and with all the important matters raised by correspondents at home and abroad. It is also his duty, and it is a very pleasant and interesting side of the Kew work, to keep himself informed as to the progress of botanical and agricultural affairs in India, the Dominions and the Colonies, and to do whatever may lie in his power to help forward their various enterprises.

The crowded shelves on the walls of the Director's room afford some evidence of the nature of the work, as any visitor to his office can see, for every folio bears in large letters on its back the name of some dependency of the Crown or of a subdivision of India, or of a Dominion. In fact, a stranger might well think that he had inadvertently entered the office of the President of the Royal Geographical Society or the room of the Secretary of State for the Colonies in mistake for the Director's Office at Kew.

The average daily post bag also reflects very clearly the Imperial nature of the work of Kew. Letters and parcels come from every part of the world, and may relate to such varied subjects as the possibility of introducing the mulberry tree to British Honduras; the Panama disease of bananas; the suitability of Newfoundland lichens for reindeer food; the precautions that should be taken to prevent undue destruction of the oil palm in West Africa; the identity of the seeds in a mixture of chicken food, a query possibly involving some legal action; or as to the botanical identity of a tropical plant about which all information is withheld by the senders, who we subsequently find are interested in the promotion of a company for its exploitation. In the latter case, I think the enquirers would be a little disturbed did they know how much we had been able to discover about their plant, bearing some camouflaged name, both as to its country of origin, chances of success under cultivation and so on.

There is also the extensive and more purely scientific correspondence to be attended to with botanical establishments on the Continent and in America, Java and the East as well as with our colleagues in our home universities and colleges.

Visitors, too, are sometimes almost as numerous and varied as the letters, for like them they come from every part of the world, and serve as a pleasant reminder that the work of Kew is appreciated throughout the Empire, and their visits to Kew help to strengthen that tie of mutual sympathy and intercourse the value of which we fully realise. That several members of the staff have personal acquaintance with most parts of the world enables Kew to give more useful

advice and criticism than might otherwise be possible.

I hope I may have been able to give you some small idea of what the work of Kew really is, and that though this work is pre-eminently scientific, Kew is, nevertheless, keenly alive to the interests that make countries prosperous and wealthy. In the words of Sir William Thiselton-Dyer—which are, I believe, as true now as when they were written over forty years ago—Kew "has itself grown and flourished under its past and present Chiefs . . . not so much from its dependence upon their merits, but rather because the principles of its administration have been essentially British and practical.

"It has steadily set itself to do every kind of public work which is connected with botanical science.

"It was never launched with a theoretically complete equipment and constitution, but it has slowly earned every advantage that has been conceded to it, and, as its labours have been enlarged, so its capacity for their performance has been increased."

The following testimony, extracted from a speech by Mr. Joseph Chamberlain in the House of Commons on August 2nd, 1898, will show how much, in the opinion of the most famous of Colonial Secretaries, the Colonies owe to Kew: "I do not think it is too much to say that at the present time there are several of our important Colonies which owe whatever prosperity they possess to the knowledge and experience of, and the assistance given by, the authorities at Kew Gardens. Thousands of letters pass every year between the authorities at Kew and the Colonies, and they are able to place at the services of those Colonies not only the best advice and experience, but seeds and samples of economic plants capable of cultivation in the Colonies."

I have attempted to show how much of what Kew has become is due to the initiative and foresight of Sir Joseph Banks and Sir William Hooker, and I think if it were desired to place an inscription beneath a monument to either of these great men, relating to their work at Kew, the following verses from the Book of Ecclesiasticus, which refer to "Wisdom," might very fittingly be selected :—

"I came out as a brook from a river, and as a conduit into a garden.

"I said, I will water my best garden and will water abundantly my garden bed; and lo, my brook became a river, and my river became a sea."

DISCUSSION.

The Chairman said that they had listened to an exceedingly interesting and very complete account of a famous Institution. He supposed that Kew and perhaps the waxworks in Marylebone Road were the two best-known places in London, not only to the provincial, but to the foreigner. He had often been surprised, while talking to foreigners in different places, by their knowledge of Kew, which was the one place that they wanted to come to England to see. It was no little privilege to be associated with a Garden such as Kew, and he entertained a certain envy of the lecturer. Dr. Hill had told them something of the history of Kew during the last 150 years. In seeing Kew to-day one was sometimes apt to forget the wonderful services which had been rendered to the Garden in time past by the pioneers, especially the two Hookers, father and son; and there were many other botanists that one might mention whose names came to mind. He remembered Sir Joseph Hooker in one or several of his letters complaining that the young botanists of his day did not know their plants, and the speaker was afraid that this was still true of some of the older botanists. Many botanical students, while having an intimate acquaintance with the insides of plants, had only the slenderest knowledge of their outsides. He himself had been more or less brought up in that sort of school. He was not going to complain of his teachers, because he felt nothing but gratitude towards most of them; but it was the fact that at that time—and he was afraid that the schools were yet not quite free from the reproach—one learned a good deal of the microscopic characters of plants without knowing what the plants themselves looked like. Students could improve their education at Kew in that respect. One thing that always struck him about Kew was that it appealed to every sort of person, not only botanists, but all men who had any aesthetic sense (and most people had some). The botanist himself approached Kew with a sense of awe, while the ordinary non-botanical person who went there, probably walked about as if the place belonged to him. He himself remembered going to the Director's office—long before the time of the present Director—in fear and trembling, though he found when he got into his presence that the Director was a human being, and indeed his experience had always been that the Directors of Kew were essentially human. So long as that state of affairs continued, the fortunes of Kew might safely be left in their hands. A great deal had been heard that evening about the work which Kew had done and was doing—its variety and utility. But he thought that Kew might even do a little more than it was doing, and he hoped that in future it would develop along new lines of activity. There was still room for expansion at Kew on the experimental side, and the best wish one could express for its future was that it might go on developing in the

future with the same rapidity as in the past. They had been told that evening that science never liked to beg. As a matter of fact, he thought that the lecturer had begged very nicely, and he would be very glad—he did not wish to appear as a rival beggar—if an additional endowment could be obtained for that wonderful book, the *Index Kewensis*. That was a work to which every botanist owed a great deal, and to which he turned very frequently for information, and he would like to support the appeal which had been so delicately made that evening by the Director of Kew.

PROFESSOR F. W. OLIVER, F.R.S., said that the Chairman had called upon him to speak probably because he knew that the first half of his life was spent in the Gardens as the son of an official, and that he could speak quite freely. He had always been an admirer of Kew, as well as its critic. His criticisms, however, he reserved for private consumption. Nor was he going to indulge in reminiscences of those early days when he lived in the Gardens, except to say that his recollections of fifty years ago were extraordinarily vivid because Kew to him then was naturally the centre of his world, as well as the centre of the botanical world. In the sixties and seventies of the last century the dominant element in botany was the systematists. They occupied all the principal positions in the botanical world, and with them resided the power of conferring appointments upon others. If at that time a botanical post was desired one naturally made friends with the Hookers or their successors. That state of affairs had gone and could never return on account of the enormous subdivision and development of the branches of botanical science. But in those days the whole botanical world used to come to Kew and reside for a week or a month or more on Kew Green, especially in the Long Vacation. Dozens of the most eminent botanists, British and foreign, were to be seen there. All this left an indelible impression on his mind, the more so because they used to talk quite freely to him, and say what they thought of Kew. They agreed that it was a most wonderful place, and then they held up their hands and said, "But, you know, the whole thing is simply wasted. Not more than one per cent. of the resources and material at Kew is utilised in any way whatever in the advancement of knowledge." What they meant was that all the plants that could be grown in the world were being grown at Kew, but that was all; the harvest was rich, but the reapers were few. The other point he remembered was this, that he and others would utilise Kew in an illegitimate way—bird-nesting, for example. Kew had an extraordinary range of birds and bird-nests, and he learned most of his ornithology in Kew Gardens. Occasionally he would use a gun for shooting game birds, sometimes even out of season! But one felt that Kew at that time sadly lacked the element of youth. This systematic aspect of botany got a little bit upon one's nerves. One of the most happy episodes in the development of Kew was the foundation of the Jodrell Laboratory, to which Dr. Hill alluded, and particularly the association with it of Dr. Scott. When the history of botany at the end of last century and the beginning of the present century came to be written the work done in the Jodrell Laboratory connected with Dr. Scott would receive full justice. His was a most extraordinary output from one man, and the number of young people he interested in the subject of botany as a whole was quite remarkable. Almost every botanist for the last forty years had passed under the influence of Dr. Scott, and lasting and extraordinary benefits had resulted to all of them. The speaker's last point was to suggest that something in the nature of an *entente* might come about between Kew Gardens and, if not a university, a sort of department of botany or botanical institute, which would have the privilege of using Kew and advancing the knowledge of the subject. He was not implying any blame to anybody, but it was perfectly impossible for the officials of a Garden to succeed in the double duty of administration and of advancing to the full the knowledge of the subject. At one time he was almost thinking of getting up a syndicate to carry out this idea—in other words, to acquire Gloucester House close by and convert it under a syndicate into a botanical institute; but that never came to anything, and the building was taken over as a college for the training of miners and other working-men who became leaders of labour. Any such development might not come within the next twenty or thirty years, but he felt sure that at some time or other an educational side would develop in connection with Kew, in the most friendly relations with the Gardens, and yet not under their authority. Kew was a Government institution, and it was out of the question to have an educational body under the orders of a Government office, although too often one found that such was the relationship. The name of Sir Joseph Banks had been mentioned that evening. Banks was not merely a botanist, he moved in the great world and knew everybody. Those who had read the Farington Diaries, lately published in the *Morning Post*, would have noted with pleasure the frequent appearance of Sir Joseph Banks, not only in social engagements, but on his travels, in his illnesses, and at his eatings and wine-drinkings. The Diaries showed that Banks was very human, in which respect he resembled the Directors of later times. Those must have been great days, when men were still in touch with the tradition of Linnaeus, who made the subject of botany more popular, he supposed, than it had ever been before, and certainly than it had ever been since. Linnaeus made certain aspects of botany at once accessible to common men. There was no more fashionable pursuit 160 years ago than the study of botany. Whether those days would ever come back again or not it was impossible to say; probably they would not.

DR. J. A. VOELCKER said that he could not claim, like the last speaker, to have spent his early days

at Kew. He had to speak rather from the point of view of the ordinary visitor, and as such he would like to be the medium of expressing the great indebtedness of the public to those who directed such a place as Kew. He did not know what others thought, but he had often remarked, on his periodical visits, that he always came away feeling that he had got something for the payment of his imperial taxes! Whether people simply walked round and enjoyed the sight of the plants and the museums and ended up with tea at the Pagoda, or whether they went with more serious intentions, they must always feel, he thought, that they had got something for being citizens of the Empire. But for those who knew the subject more closely there was a much wider sphere of interest at Kew, and it was very instructive to have heard from the Director himself an account of the history and of the present activities embraced under the name of Kew. If he might be allowed as a layman to speak from his own experience, he would like to acknowledge the courtesy and the readiness to help which resulted from addressing inquiries to Kew. In his own agricultural work he had had from time to time to refer questions to Kew, and it was almost unnecessary for him to say that the officials there were willing to go to endless trouble in satisfying the requests of those who applied to them. The British public did not fully know of this; they did not realise that institutions such as Kew were there for the purpose of affording information to inquirers, and the number of questions which the obliging officials there were able to answer was remarkable. We needed to be reminded that Kew was a national possession. It was one of the places to which we had a right to go, and if the public did not use the stores of information available, the fault was that of the public and not of Kew. At all events, he could say for the Directors of Kew Gardens, and now for the present Director, that they were always willing and ready to afford information to those who inquired. He could bear out from his own experience what Dr. Hill had said with regard to the influence of Kew in other parts of the Empire. It had been his lot to travel about in India, and wherever he went he found a number of people in constant touch with Kew. The Gardens at Calcutta, Saharanpur, and elsewhere were in regular correspondence with Kew. The same thing obtained in the West Indies and elsewhere. All this formed part of a vast system for the gathering together of information which was for the benefit of science, and which also served commercial interests. There were a large number of cases in which the accumulated knowledge of Kew, from purely scientific sources, had been devoted to the expansion of commercial interests. Science was not valued purely for its own sake, but for the extent also to which it could be used in the general service. He had been interested to hear of the different changes that Kew had gone through in its time, how the original plan was conceived and carried out, and how it then underwent a period of decadence, when another institution, the British Museum, came up and secured the early records of Kew. He did not know that that was altogether a bad move; it was not always a mistake to have two institutions, one keeping the other up to the mark. At all events, the old plan had been reverted to, and the system of having collectors and correspondents all over the world had been retained, and all who had listened to the lecture that evening would wish good success to that work.

Mr. E. Shine said that in the Ministry of Agriculture he had the pleasure of working with the Director of Kew. The Director had rather slurred over, in his paper, the connection with the Ministry of Agriculture, and he for his part only wished that the Ministry of Agriculture had the same interesting dealings with Kew that, he understood, the Foreign Office, the Colonial Office, and other departments of Government had. The Ministry of Agriculture's concern at Kew often related to such dull questions as to whether perambulators should be permitted to go into the Gardens, and whether the entrance fee should be a penny, twopence, or nothing at all. The Ministry of Agriculture was very glad to be connected with a department like Kew Gardens, which, he thought, was always in favour with the general public. At the Ministry they were so accustomed to people finding fault with them on such questions as rabies, foot and mouth disease, and so on, that it was quite pleasant to hear everybody exclaim that everything in the garden was lovely! So far as the officials at the Ministry were concerned, their relations with the Director and officials were always most harmonious, and they welcomed at the Ministry the privilege of being associated with them.

The Secretary said that there was one small point to which he would like to draw attention. The Director of Kew had referred at the beginning of his paper to the introduction of the bread-fruit tree to the West Indies. The speaker merely wished to point out, as a sort of foot-note to the paper, that the whole question of the conveyance of that bread-fruit tree to the West Indies was due to the work of the Society. Sir Henry Trueman Wood, in his History of the Society, related how Sir Joseph Banks, who was a member, took a great interest in this question, and it was on his suggestion that a prize was offered with this particular object. As a result of that prize, Captain Bligh undertook his expedition on the "Bounty." He failed the first time, but on his second expedition, in 1793, he succeeded. On his return he sent in a full report of the whole affair to the Society, and as a result of that he was awarded the Gold Medal.

The Chairman felt sure that the audience would wish to express its hearty thanks to the Director of Kew. He could only say for himself that although he had been more or less familiar with Kew for some time, he had been somewhat ignorant of its past history, and had not realised the full extent of its activities until that evening. It would be

a great advantage to many to have this paper in a form in which it could be readily referred to, and he was very glad that it was going to be printed in the *Journal*. It would be a most valuable paper for reference.

A vote of thanks was passed unanimously.

DR. HILL briefly acknowledged the compliment, and the meeting terminated.

NOTES ON BOOKS.

LIFE OF SIR WILLIAM WHITE, K.C.B., F.R.S., LLD., D.Sc. By Frederick Manning, with an introduction by The Rt. Hon. Lord George Hamilton, G.C.S.I., LL.D., D.C.L. London: John Murray. 1923.

Sir William White died in 1913 at the age of 68, so that it is time for his life to be written, if it is to be read by any of his contemporaries. Not very many of them can still survive, and the list is rapidly diminishing. One of them, Lord George Hamilton, fortunately is still alive and contributes, as an introduction to this volume, a warm and generous appreciation of Sir William's character and public service. Lord George and Sir William White were born in the same year. One was First Lord of the Admiralty when the other was appointed Director of Naval construction, and the mutual liking and admiration conceived by each for the other continued till Sir William's death.

Sir William White's life just synchronised with the era of change brought about by the introduction of steam as a motive power, and the substitution of iron for wood in the construction of war-ships. The first work on which he was employed as a dockyard apprentice was the conversion of a sailing ship into a screw-propelled steamer. When he resigned his post at the Admiralty, British war-ships had become the huge swift engines of destruction which saved the country from invasion in the great war which began a year after his death.

From the time of Elizabeth till the day of Trafalgar, there had been no great change in our ships, and in the half-century which followed Trafalgar the improvement had been but small. Now, a single modern line-of-battleship (given, of course, a sufficient supply of ammunition) could send to the bottom, herself uninjured, the great Armada and the English ships which drove it to destruction, or the combined fleets which fought at Trafalgar.

It is not, of course, suggested that these great changes were in any sense due to Sir William White. Things would have taken the same course had he never lived, and even when they were modified by individual direction, he was only one of many whose influence affected the direction of change and its character; but he took his full share of the work. To call him "the greatest naval architect this world has ever seen," is to make rather a strong statement, but certainly among his contemporaries he had few, if any, equals, and certainly no superior.

He started in life as a dockyard apprentice, after a discussion, it would appear, between some of his friends as to whether he should not be trained for the Baptist Ministry. Fortunately, alike for the boy and for the public service, the wiser counsel prevailed and he entered the Royal dockyard at Devonport in 1859. Not very long after his apprenticeship (in 1869), the School of Naval Architecture was founded at South Kensington and White was one of the candidates selected from the various dockyards. He passed at the head of the list in the competitive examination and remained at the school till he entered the construction department of the Admiralty in 1870. In the same year the School was merged in the Royal Naval College at Greenwich, and White, who had become Instructor of Naval Architecture at the school, became one of the Lecturers at the College.

At the Admiralty he remained till 1883 holding various appointments, the highest being that of Chief Constructor. In that year he received an offer from Sir William Armstrong which led to his employment by the great Elswick firm. With them he remained till 1885, when, on the resignation of Sir Nathaniel Barnaby, he was recalled to the Admiralty as Director of Naval Construction. White's acceptance of this post was a distinctly patriotic act, for in spite of its high distinction, its emoluments were less than he was receiving, and would have received at Elswick. If he had remained at Armstrongs he would certainly have died a much richer, and probably a happier man. The service of a great commercial firm is free from many of the drawbacks of service under superiors whose actions and decisions must of necessity be influenced very largely by political considerations; and besides discharging the duties of a difficult post, he had to meet the parliamentary criticism of a former holder of the same office, neither an easy nor an agreeable task.

The policy of the Admiralty, and the work of its construction department were the subject of vigorous, even violent, controversy, alike Parliamentary and professional. The Director of Naval construction was not only permitted, but expected to take his part in it. This White did with much effect, both at the professional associations, such as the Institutions of Naval Architects and of Civil Engineers, and before more popular audiences in his lectures and addresses at the Society of Arts, and the British Association.

He held his office till 1902, when he resigned. His resignation, partly due to failing health, was precipitated by a blunder made in the construction of a Royal Yacht, for which he was nominally though not actually, responsible. The work which he carried out during his 17 years' tenure of office is described in full detail by Mr. Manning, and the record is a long and honourable one.

When he left the Admiralty he was disposed to retire entirely from further work, but the advice and solicitations of several warm friends induced him as his health recovered, to resume. He became

a Director of the firm of Messrs. Swan and Hunter and in that capacity assisted in the design and construction of the two great Cunarders, Mauretania and Lusitania.

He was President of the Civil Engineers in 1902, and was President-elect of the British Association at the time of his death. He was Chairman of the Council of the Royal Society of Arts in 1908, and was one of its Treasurers at the time of his death. The warm interest he took in the Society during the closing years of his life was increased by the fact that as a boy he had been very successful in its examinations and had taken a number of certificates.*

Reference has already been made to Lord George Hamilton's generous eulogy of Sir William White's public services and personal character. Perhaps it may be permitted to another contemporary who knew Sir William well during the last years of his life, and was closely associated with a certain portion of his extra-professional activities, to conclude this notice with a word of tribute to his kindly nature and unselfish disposition. He was always ready to promote any cause which appealed to his sympathy, to help any institution which deserved his aid, and his death ten years ago, was mourned by a large circle of friends who appreciated his abilities, and regarded with affection his kindly generous nature.

H. T. W.

* Fuller details of Sir William White's association with the Society will be found in the obituary notice in the *Journal*, 7th March, 1913.

OBITUARY.

Sir Henry Kimber, Bt.—Sir Henry Kimber died at his residence in Putney on December 18th, at the age of 90. He had been a member of the Royal Society of Arts for 47 years, having been elected in 1876.

Born in 1834, he was educated at University College, London, and was admitted a solicitor in 1858. He founded the well-known firm of Kimber and Ellis, now Kimbers, Williams and Co., from which he retired in 1890. During his professional career of 40 years he was engaged in many famous cases, prominent among which were the "Balham Mystery" and the scandals in connection with the Grosvenor Hotels Company.

Sir Henry Kimber was a director or chairman of many railways and industrial companies, including, among others, the South Indian Railway, the Pondicherry Railway, the Royal Swedish Railway, the Capital and Counties Bank, the Natal Land and Colonization Company and the Colonist Land and Loan Corporation. He entered Parliament as conservative representative of Wandsworth in 1895, and retained the seat till 1913. He worked hard in the endeavour to correct electoral anomalies by a fair scheme of redistribution, and he rendered much valuable service on Parliamentary committees.

VENEER INDUSTRY OF FINLAND.

The veneer and plywood industry in Finland was founded during the war and has developed rapidly. There are now seven factories, with a total yearly production of about 30,000 tons of veneer. The 50 lathes in operation are being increased to 58.

The best qualities of veneer are used for furniture and ceilings, etc., the poorer qualities being used for the manufacture of packing boxes of various kinds, especially tea chests. About 30 to 40 per cent. of the exports of veneer consist of tea chests.

The exports during 1922 amounted to about 20,000 tons, being about 100 per cent. more than the corresponding figures for the preceding year. The exports have gone almost exclusively to England, small quantities only having been shipped to Belgium and the Netherlands.

It is reported by the United States Consul at Helsingfors that one of the largest veneer factories in Finland has been greatly enlarged of late and has taken up the manufacture of a new veneer called "Tarso," said to be patented in 15 countries. The manufacture of "Tarso" veneer consists of imitating inlaid work and wood mosaic on veneer by means of photography in such a way as to show all original colours, these being burned into the wood. The price of "Tarso" veneer is stated to be only about three times that of common veneer and an unlimited number of copies may be made from a plate. It is expected that "Tarso" will find a good market, especially in the cabinet-making industry.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock:—

January 23.—G. Albert Smith, "Cinematography in Natural Colours—further Developments" (with illustrations—scenes from H.R.H. The Prince of Wales's Tour in India).

January 30.—Sir Richard Arthur Surtees Paget, Bt., "The History, Development and Commercial Uses of Fused Silica." Sir Herbert Jackson, K.B.E., F.R.S., will preside.

February 6.—Iyemasa Tokugawa, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

February 13.—H. Maxwell-Lefroy, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle." Sir Aston Webb, K.C.V.O., C.B., P.R.A., will preside.

February 20.—Percival James Burgess, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber."

FEBRUARY 27.—

MARCH 5.—MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries."

MARCH 12.—ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, "Recollections of some Notable Scientific Men." (Illustrated by Photographs.)

MARCH 17.—R. L. ROBINSON, Member of the Forestry Commission, "The Forests and Timber Supply of North America."

MARCH 24.—NEAL GREEN, "The Fishing Industry and its By-Products."

Dates to be hereafter announced :—

SIR LYNDEN MACASSEY, K.B.E., "London Traffic."

CHARLES S. MYERS, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation."

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock :—

JANUARY 4.—BRIGADIER-GENERAL H. A. YOUNG, C.I.E., C.B.E., late R.A., Director of Ordnance Factories, India, 1917-21, "The Indian Ordnance Factories and Indian Industries." GENERAL SIR EDMUND BARROW, G.C.B., G.C.S.I., Member of the Council of India, will preside.

JANUARY 18.—COLONEL H. L. CROSTHWAIT, C.I.E., R.E., retd., late Superintendent, Survey of India, "The Survey of India." Sir THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., Rector, Imperial College of Science and Technology, will preside.

FEBRUARY 15.—SIR RICHARD M. DANE, K.C.I.E., Commissioner North India, Salt Revenue, 1898-1907; Foreign Chief Inspector, Salt Revenue, China, 1913-18, "Salt Manufacture in India and China."

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons at 4.30 o'clock :—

FEBRUARY 5.—F. W. WALKER, "The Commercial Future of the Backward Races, with Special Reference to Papua." SIR GEORGE R. LE HUNTE, G.C.M.G., will preside.

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

Date to be hereafter announced :—

THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak."

CANTOR LECTURES.

ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." Three Lectures. January 21, 28; February 4.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25, March 3, 10.

COBB LECTURES.

Monday evenings, at 8 o'clock :

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

DR. MANN JUVENILE LECTURES.

(*Special tickets are required for these Lectures.*)

Wednesday afternoons, at 3 o'clock :—

DR. WILLIAM ARHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology. "Fire and Explosions." Two Lectures, January 2, 9. The Lectures will be fully illustrated with experiments.

MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, "Among the Selkirk Mountains of Canada (with ice-axe and camera)." One Lecture. January 16. The Lecture will be fully illustrated with hand-painted lantern slides.

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FRIDAY, JANUARY 4, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICE.

NEXT WEEK.

WEDNESDAY, JANUARY 9th, at 3 p.m. (Mann Juvenile Lecture.) DR. WILLIAM ARTHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology, "Fire and Explosions." (Lecture II.) The lecture will be fully illustrated with experiments.

Special tickets are required for this course and for the Mann Juvenile Lecture by MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, entitled "Among the Selkirk Mountains of Canada (with ice-axe and camera)," to be delivered on Wednesday, January 16th, at 3 p.m. A few tickets for both courses are still left, and these will be issued to Fellows who apply for them at once.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

SIR GEORGE BIRDWOOD MEMORIAL LECTURE.

FRIDAY, DECEMBER 7TH, 1923.

SIR CHARLES STUART BAYLEY, G.C.I.E., K.C.S.I., in the Chair.

THE CHAIRMAN said that it was with very great regret that he had to announce what, he knew, would be a grievous disappointment to the audience, as it was to himself—that the Secretary of State for India was unable to be present to take the Chair. Lord Peel had looked forward very much to presiding that afternoon, and had written him the following letter:—

India Office,
London, S.W.1.
7th December, 1923.

"My dear Sir Charles,

"It is with very keen disappointment that I find myself prevented at the eleventh hour from carrying out my promise to preside at the Sir George Birdwood Memorial Lecture this afternoon. Unfortunately elections are no respecters of ministers, whether members of the Lower or Upper House; and I to my cost have paid the penalty by succumbing to an attack of election sore throat, which makes it quite impossible for me to speak with any pleasure to myself or my hearers. My only course is to submit to this infliction and to treat it patiently with two or three days' rest. I must ask you to express my most sincere apologies to the Royal Society of Arts, to Mr. Digby, the Secretary, and above all to Mr. Foster, to whose lecture I had been looking forward with that keenness of interest which must inspire everyone who knows his record and hopes to hear him speak on a subject which he has made so peculiarly his own. Will you please also express to those who will be attracted by Mr. Foster's name to come to the meeting this afternoon my envy of their good fortune which it is not my privilege to share?

Yours sincerely,

PEEL.

In the circumstances it had devolved on himself, as Chairman of the Indian Section of the Society, not to fill Lord Peel's place, because he could not pretend to do that, but to occupy the Chair, and in that capacity he had the great pleasure of introducing Mr. Foster. It was superfluous to do so, because to everyone who was interested in India as she had been, and to a great extent as she is to-day, Mr. Foster's name was thoroughly well known. Everybody knew how Mr. Foster had worked in the India Office, and what valuable work he had done. What everybody did not know was a secret which he had recently learned with surprise, namely, that Mr. Foster's labours in the India Office had extended over a period of more than 40 years. In that time Mr. Foster had acquired an unrivalled knowledge of the activities of the East India Company and of the Administration of India under the Crown, and the results of his researches and studies were embodied in works which now formed a part of every decently equipped library dealing with Indian subjects. In the ordinary course, Mr. Foster would have retired at about the present time, but, happily for India and for students of Indian history, official routine had not been allowed to deprive India of his services, and he now appeared, no longer as Registrar but under the more dignified and appropriate title of Historiographer. They all congratulated Mr. Foster and themselves on the fact that he was staying on to continue his work and that such a high honour had been bestowed upon him.

THE ARCHIVES OF THE HONOURABLE EAST INDIA COMPANY.

By William Foster, C.I.E.,
Historiographer, India Office.

Previous lectures in this series have recalled to our memories Sir George Birdwood's affection for the peoples of India and the services he rendered to that country both in the promotion of its industrial arts and in securing a proper appreciation of Indian artistic skill, alike in painting, sculpture, and architecture. This afternoon it is my privilege to discourse upon another subject to which his many-sided genius paid no small amount of attention, with results that still claim our gratitude.

For the reason of his interest in the history of the relations between India and this country we have not far to look. His connexion with Plymouth, not only as the home of his ancestors but as the scene of his own boyhood, had imbued him with a veneration for the sixteenth and seventeenth century navigators; while the picturesque side of the trade, especially in the early days, appealed strongly to his vivid imagination. Moreover, to say nothing of collaterals, his father, grandfather, and great-grandfather had been, like himself, in the service of that Company which, as he once wrote, was in his eyes "the greatest and most beneficent trading organisation of any age or nation." Intensely patriotic, he gloried in the stirring story of the acquisition of British supremacy over the Indian peninsula; and to him every detail of that story was of interest, and every document relating thereto was sacrosanct.

The earliest sign of his attention to the subject of the Anglo-Indian records was given by an anonymous communication to the *Athenaeum* of 22nd February, 1873, in which he commented sarcastically upon the destruction of documents that took place after the transfer of the records to official custody. Not long afterwards he received, in his capacity of Curator of the Museum, a box which had been lying for some time in the Political Department; and this, on being opened, proved to contain forty parchment documents, including many of the Company's charters. On these Dr. Birdwood (as he then was) submitted in April, 1875, an interesting report, in which he had the assistance of Mr. W. N. Sainsbury, of the Public Record Office. Subsequently he was asked to examine and report upon a large collection of records, chiefly of the seventeenth century, which had never been closely investigated. The main body of the records, from 1702 onwards, had always been well cared for, both at the East India House and at the India Office: but these relics of an earlier time had been comparatively neglected. In November, 1878, Birdwood presented a detailed report, dwelling with enthusiasm upon the great value of the collection, especially in relation to the economic history of India. The report was not made available for general use until 1891; but copies of the official edition were widely circulated, and the interest thus aroused contributed largely to the creation in 1884 of a Registry and Records Department at the India Office, under Mr. F. C. Danvers. The measures thereupon taken to classify and publish the official archives never lacked Birdwood's support and the benefit of his advice; while he himself took no mean share in the work of publication. When in 1886 the first volume of the East India Company's Court Minutes was published at the expense of an American (Mr. Henry Stevens), Birdwood contributed an admirable preface. This led to an offer from Mr. Quaritch to publish another volume of records, to be chosen and edited by Sir George, and the result was the issue in 1893 of *The First Letter Book*. Another example of his interest in the subject is the work entitled *Relics of the Honourable East India Company*, published in 1909. This volume is lying in a prominent position on his desk, in the picture I now show, which represents Birdwood seated in his room at the India Office.

In saying something to-day about the Company's records, I do not propose to weary you with an elaborate account of their classification and contents. That side of the subject has been dealt with in a paper read before this Society by Mr. Danvers in 1890; and, moreover, about five years ago the India Office issued a little handbook intended to guide the student through the labyrinth of archives. I might dwell upon the fact that the India Office collection is the second largest accumulation in England: that in range of subject it approaches the Public Record Office itself: that it provides better material for the history of India

than can be found in any Indian record office: that in addition it contains masses of information about other parts of the Empire, such as Ceylon, the Cape, St. Helena, the Straits Settlements, and also about China, Japan, Egypt, Persia and other Asiatic countries. All this, however, is perhaps already known to you; and my aim this afternoon will be to enable you, with the aid of illustrations, to gain some idea of the more important classes of documents, and thereby to understand the value and interest of the historical materials which still await investigation by students.

The first series to which your attention is directed is that known as the Parchment Records, which includes many of the charters granted to the East India Company. Of these the earliest now surviving is that granted by Charles II. on 3rd April, 1661, the last sheet of which is here shown. As will be seen, the document has been sadly misused. Part of the ornamental border has been cut off; and although the arms of the Company (*i.e.*, the arms of the Old Company, 1600-1709) are still at the top of the page, the corresponding drawing at the bottom has been stolen. The seal, too, is missing. This charter is a landmark in the history of the Company, granting, as it did, power to make war or peace with non-Christian nations, to fortify settlements, and to maintain garrisons. Such powers were sought, not with any aggressive aim, but solely to legalize the Company's position. It already possessed fortified settlements at Madras and St. Helena, for which soldiers had to be recruited; while its right to conclude agreements with Asiatic Powers had recently been called in question.

Our next illustration reproduces the first page of a volume containing the subscriptions towards the two million loan which was the condition for the establishment of a new East India Company, under the authority of an Act of Parliament passed in 1698. The subscription list was opened at Mercers' Hall on 14th July, 1698, and Macaulay has described the rush of investors to enter their names. On the page here shown the first entry is one of £10,000, subscribed by the four Lords of the Treasury on behalf of King William III. All four subscribed also on their own behalfs; while among other names we notice those of the Duke of Shrewsbury, the Earl of Portland, the Earl of Montagu, the Earl of Ranelagh, and the Earl of Orford (better known as Admiral Russell, the victor of La Hogue). The seals and signatures underneath are those of seven of the commissioners appointed to superintend the reception of the subscriptions.

As a consequence of the success of this subscription, a royal charter was issued on 5th September, 1698, establishing a new East India Company. It is a sign of the changed circumstances that this charter (of which the first sheet is now shown) is expressly stated to be issued in accordance with an Act of the legislature, whereas previous grants had been made at the will of the sovereign. In the top left hand corner will be noticed a portrait of King William.

One clause in this charter required the Company to put a chaplain on board every vessel of 500 tons or upwards. The result was that, for the next three quarters of a century, the Directors carefully avoided chartering more than 499 tons in any one ship.

Following that charter we have the grant of arms by the College of Heralds to the New Company, dated 13th October, 1698. These arms were adopted by the United Company when the old and new bodies were amalgamated in 1709, and they continued to be used down to 1858. The crest —irreverently nicknamed the "cat and cheese"—was often used separately as a badge of the Company, and it may still be seen on many of the chairs in the India Office.

Another document belonging to the same collection is an original letter from James I. to Shah Abbas of Persia, dated 14th February, 1622, requesting the Shah to favour and protect the English merchants trading in his country. This letter found its way into the possession of the Koninglijk Oudheidkundig Genootschap of Amsterdam; and in 1894 that Society, at the instance of Mr. Danvers, generously presented it to the India Office. It is particularly interesting as a specimen of the royal letters which, in the early part of the seventeenth century, were freely sent to Eastern monarchs at the suit of the East India Company; and, doubtless, the letter which Sir Thomas Roe presented to the Emperor Jahangir at the time of his embassy was similar in appearance to the document on the screen.

Turning to the administrative records, the first section that claims our attention is that of the Court Minutes, of which, with a few exceptions, the India Office possesses

a complete series from 1599 to 1858. The first example to be shown is part of the record of the meeting held on 24th September, 1599, to arrange for the despatch of an expedition to the East Indies and to elect representatives to manage the details. The list of those present contains some interesting names. It is headed, as will be seen, by Alderman Sir John Hart, who had been Lord Mayor in 1589-90. He was elected Governor of the Company in 1602, but refused to serve. Then come four more Aldermen, including William Halliday, who was Governor from 1621 until his death in 1624. The next person mentioned is Richard Staper, whose promotion of the journey of Ralph Fitch to India in 1583 is well known; while lower down will be found the name of John Eldred, who was one of Fitch's companions for part of the way on that memorable expedition.

Skipping a period of over sixty years, we come to the time of the Great Fire. Here is the record of the first Court meeting held after that calamity, namely, on 10th September, 1666. Though the East India House escaped the flames, it was for a time in danger, and the books and other objects of value were hurriedly removed to Mile End and Stepney. At this meeting they were ordered to be brought back, and the thanks of the Court were awarded to those who had superintended the removal. A refusal was also given to the request of a haberdasher, whose premises had been burnt and who hoped that the Company would let him have part of the front of their house for a shop.

It would be easy to spend the rest of our time in producing entries of interest from this valuable series; but I must limit myself to one more, and that shall be the record of the vote (on 24th April, 1799) of £10,000 to Lord Nelson, in recognition of his victory at the Battle of the Nile—a victory which shattered Napoleon's dream of making Egypt a stepping stone for the invasion of India. It will be seen that an attempt was made to reduce the grant to £5,000, but in the end the original proposal was carried. The next slide shows Nelson's effusive letter of acknowledgment (written, of course, with his left hand). In it he refers to the fact that in his younger days he had himself served in the East Indies. The original letter, framed, now hangs in the reading-room of the India Office library.

From the Court Minutes we may go to the letters sent by the Directors to their servants in the East. Down to the year 1753 those letters were copied into volumes, now known as the Letter Books. From this series we give two specimens. The first is a page of a letter to Surat in March, 1668, announcing that the King has been pleased to bestow upon the Company the Island of Bombay, and ordering that possession should be taken as soon as possible. Directions are given for "the establishing of a good government," and the factors are enjoined to "incorage the natives that are there and invite others to come thither." The second specimen is part of a letter addressed to Madras on 12th December, 1687. It is generally assumed to have been dictated by Sir Josia Child, who was then Governor, and it contains the oft-quoted passage in which a hope was expressed that the hostilities then being carried on with the Mogul authorities in Bengal would result in laying "the foundation of a large, well-grounded, sure English dominion in India for all time to come"—an expectation that was woefully disappointed by the outcome of the war. The importance attached by the Directors to clear handwriting is well shown by the penmanship of this series and the Court Minutes.

From 1753 onwards the copies kept at the East India House of letters sent to the East were arranged in several series, according to the Presidency to which they were addressed. These comparatively modern documents have not the quaintness of the earlier ones, and I have not thought it necessary to show any of them this afternoon. One special feature (with which it is difficult to deal by means of photography) is that from 1784 onwards they show the red-ink alterations made in the original drafts by the Board of Control—the Government department formed in that year to supervise the Company's administration in all branches save that of commerce.

An interesting example of the conservatism of the Company is the fact that, from the very beginning right down to 1858, the Directors' letters were subscribed "Your loving friends." Sir George Birdwood once quoted this as a proof of the excellent relations that subsisted between the Company and its servants; but I fear that, when it closed (as it often did) a letter of stinging rebuke, it was regarded by the

recipients as nothing more than a conventional formula.

From the letters sent to the letters received is an easy transition; and here we have the added interest that in most cases we are dealing with originals, not copies. For the seventeenth century these documents are mostly to be found in one collection, known as the "Original Correspondence." From its riches it is difficult to make a selection; but I now show three specimens. The first is the earliest of the letters now extant. It was written at Bantam (in Java) on 16th December, 1607, to advise the Company of what was happening in that distant factory, and was received in September, 1608. As will be seen, the document has suffered some damage, and parts are difficult to decipher. One of the signatories, Gabriel Towerson, was the chief of the Englishmen put to death by the Dutch in 1623, in what was called the "Massacre of Amboyna." The next slide reproduces a letter from Sir Thomas Roe, whose embassy to the Emperor Jahangir is well known. This epistle, which is in the ambassador's handwriting, was dated at Ajmer on 27th April, 1616, and addressed to the Rev. William Lescke, the chaplain at Surat. In it, alluding to the Mogul Court, Roe says: "I never imagined a prince so famed could live so meanly. All his wealth is no woonder; the Norose [*Nauroz*], at which tyme all is exposed, is a poore May game. Religions infinite, lawes none. In this confusion what can bee expected?" As an accompaniment to this letter, a portrait of Roe may be of interest. It is from the painting in the National Portrait Gallery, which is considered to be a copy of the original portrait by Miereveldt.

The third specimen is part of a letter from the Bengal factors to the Company, dated 30th September, 1689, and signed by Job Charnock (whose name is for ever associated with the founding of Calcutta), Francis Ellis, Jeremiah Peachey, and John Beard. In it the writers reaffirm their conviction that "Chutanuttee" (the future Calcutta) is the most suitable place for the headquarters of the English in Bengal. Ellis succeeded Charnock as Agent at Calcutta; while later on Beard held the same post, with the higher title of President.

The next exhibit is the concluding portion of a letter from Fort St. David, dated 17th October, 1746, announcing that Madras had been captured by the French on the 10th of the preceding month. The letter is signed by the Governor and Council of Fort St. David, which, in consequence of the loss of Madras, had become the seat of government.

By way of counterpoise to this melancholy document, I next show a holograph letter from Lord Clive, written on 18th April, 1757, congratulating the Company upon the capture by his troops of Chandernagore, the headquarters of the French in Bengal. It is a brief, soldierly epistle, which yet conveys something of the force and directness characteristic of that remarkable man. As a pendant I insert here a portrait of Clive, from the painting by Sir Nathaniel Dance, in the National Portrait Gallery.

Turning now to more peaceful subjects, here is a holograph letter from Warren Hastings to the Secretary of State (Lord Rochford), dated 4th December, 1774, expressing his gratification at having been appointed Governor-General, and lamenting the differences that had already arisen between him and his new colleagues from England.

Another great name is recalled by the succeeding slide, which reproduces a letter from Lord Mornington (afterwards the Marquess Wellesley), announcing to the Court of Directors that he had arrived in India and had assumed charge of the post of Governor-General. Only one side of the letter appears in the photograph.

Next comes part of a letter from His Lordship's brother, Sir Arthur Wellesley, the future Duke of Wellington. It was written from No. 11, Harley Street, on 11th April, 1807, and forwarded to the Directors a memorandum correcting certain erroneous statements concerning the battle of Assaye.

After seeing so many documents, it may be a relief if I give three or four slides representing the East India House itself. The first view is of the original building on the site, known as Craven House, owing to its being the property of Sir William Craven and his son, the famous Earl of Craven. This building was rented by the Company in 1648, and purchased about sixty years later. The representation here given is taken, as you will see, from the shopbill of William Overley, a joiner, who is shown in the foreground as occupying a small shop in the front of the House. The next slide shows the same premises,

after their reconstruction at the beginning of the reign of George II., though the picture itself was drawn towards the end of the century. The East India House is the long building on the right. The third view is of the House in a still later stage, when it had been rebuilt by Jupp in 1796-9. Here we are looking up Leadenhall Street towards Cornhill. In the distance are the churches of St. Peter and St. Michael. Finally, we have the Directors' Court Room. Conspicuous in this is the Chairman's seat, now used at the India Office by the Secretary of State for India. Some of those present this afternoon will recognise other items of the furniture, particularly the tables and the door, as being now in the India Office Council Room.

We next proceed to consider another great division of the records, namely, the volumes recording the consultations or proceedings of the various administrations in India. From the earliest days the Company insisted upon corporate responsibility among its servants in the East. Every matter of importance had to be debated by the factors on the spot, and records of these consultations, signed by those taking part, had to be sent home for information. As the number of factors increased, it became the practice for only the seniors to meet in consultation, and this assembly hardened into a Council of a fixed number. There is thus an unbroken continuity between the earliest meeting of a few factors at Surat and the present day deliberations of the Viceroy and his Council. The picture on the screen gives the record of a consultation held by the Surat President and his associates on 26th February, 1620, John Bickell, commanding the Fleet, being also present. The list of those attending includes Thomas Kerridge (the then President), Thomas Rastell (President in 1621-25 and 30-31), Giles James, and Edward Heynes (Roe's former secretary).

Passing over a period of 160 years, we come to a page recording the proceedings of the Government of Bengal in the Secret Department on 20th July, 1780. At that meeting the Governor-General (Warren Hastings) handed in a minute, written more than a fortnight earlier, which provoked the famous duel between him and Philip Francis. Of the latter Hastings wrote in his minute : "I judge of his public conduct by my experience of his private, which I have found to be void of truth and honour"; and directly this came to the knowledge of Francis he issued a challenge. As you all know, the result of the meeting was that Francis was wounded, and he went home not long after. It is interesting to speculate what the consequences might have been, had the encounter ended differently.

This seems to be a suitable place to introduce a portrait of Warren Hastings. It is from a painting by Lemuel Abbot, painted about 1796. Hastings himself thought it a good likeness, and distributed replicas among his friends. The photograph here reproduced is from one of these, given by Hastings to David Anderson in 1797.

A present-day subject of controversy is recalled by the next slide, which shows the entry, on the Proceedings of the Government of Bengal, of a letter from Sir Stamford Raffles, dated 13th February, 1819, announcing his occupation of the Island of Singapore, and dwelling upon the importance of the new acquisition. This document is an opportune reminder of the fact that it was to the foresight and energy of one of the East India Company's servants that this notable addition to the Empire was due. It also reminds us that the India Office records are of primary importance for the history of many of the British colonies — a fact which is slowly being recognised.

Besides the records of the East India Company, the India Office archives include the documents of the Government Department known as the India Board or Board of Control, which, as already noted, was established in 1784 to supervise the Company's administration of its possessions in the East. These records consist largely (though not exclusively) of the minutes of the Board and its correspondence with the Directors; and since they only indirectly concern the subject of the present paper, it will perhaps suffice if I exhibit one specimen, namely, part of the record of the first meeting of the Commissioners. This was held on 3rd September, 1784, when His Majesty's commission was read and those present, including, it will be seen, Lord Sydney (Secretary of State), William Pitt, and Henry Dundas, took the required oath to fulfil their duties faithfully and give their best advice and assistance for the good government of the British possessions in the East Indies.

It is often supposed—and not unnaturally—that the India Office archives must contain

a large number of documents in Oriental languages—particularly Persian, which was for so long the medium of diplomatic correspondence and the language of the Company's law courts. As a matter of fact, this is not the case. Among the very early records there are some documents in Japanese, which have been copied and published by students from that country, as interesting specimens of the language in its seventeenth century stage. Occasionally, too, one comes across documents in other Oriental languages, in most cases Persian. But this is exceptional; as a rule, the originals were not sent home, for two reasons. In the first place, they might be needed at any time in India for production in case of dispute: in the second, they would be of little or no use in England, where translations would serve all the requirements of the Company. In the latter part of the eighteenth century, however, certain Indian rulers wrote from time to time to the British sovereign; and these letters, which, of course, came in original, may occasionally be met with in the archives of the India Office. Here is a specimen, namely, a letter from Mir Jafar, Nawab of Bengal, to King George III., written apparently about the end of 1764, announcing the removal of Mir Kasim and his own resumption of the *masnad*. The Nawab begs for a reply, undertakes to pay whatever is due from him, and expresses a hope that His Majesty will order the Company's officials to abstain from interfering in the administration of the province.

Next is shown a letter in Malay, from the Sultan of Mindanao (the most southerly of the Philippine Islands) to George III., offering an alliance, offensive and defensive, and promising facilities for British trade in his country. This letter was brought home by Capt. Thomas Forrest, and is mentioned in his work entitled *A Voyage to New Guinea*.

The third slide in this section reproduces one of the original copies of the Treaty of Allahabad, 1765, signed on the one hand by Lord Clive and General Carnac, and on the other by Shuja-uddaula, Nawab of Oudh. At the top is the seal of the Great Mogul. The witnesses on the English side are Edmund Maskelyne (Clive's brother-in-law), Archibald Swinton, and George Vansittart (who was Persian Translator). This document, framed, now hangs in the reading-room of the India Office Library.

We go next to the large and important collection of Marine Records. This consists largely of the logs and ledgers of the Company's vessels, extending from 1605 to 1856, with, in addition, over 900 volumes of miscellaneous records relating to the subject. During the seventeenth century the logs were kept in ordinary books and in narrative form. Here is a specimen—the first page of Captain Saris's account of his pioneer voyage to Japan in 1611-13, with its pious invocation and heading, followed by a matter of fact recital of the course of events day by day. The greater part of this journal was printed in 1900 by the Hakluyt Society, under the editorship of Sir Ernest Satow. Early in the eighteenth century the form of the log was systematized, and specially printed books were issued for the purpose. As a specimen of these may be given part of a page from the log of the *Earl Camden*, containing Commodore Dance's account of the action between his merchant fleet and a squadron of French men-of-war off Pulo Aor in February, 1804. The record is amusingly laconic: "At noon, perceiving the enemy bear up to attack our rear, made the signal to the headmost ships and tacked towards them. At 12.10 the enemy opened their fire on the *Royal George*, *Ganges*, and ourselves, which we all returned; when about one the enemy hauled their wind to the E.N.E. Made sail after them, as did the fleet." This fight, which saved from capture a fleet of immense value, made a great sensation in England, and brought Dance a knighthood and a pension, besides presents of money to a considerable amount.

Ships' logs, we know, often supply the only records available of births, deaths, and even marriages, occurring during the course of a voyage; and this brings us to another interesting section of the records, namely, the registers of such events on land. The India Office possesses a large collection of returns giving baptisms, marriages, and burials of Europeans in the East Indies. The Madras series commences in 1698, the Bombay in 1709, and the Bengal in 1713; while there are also returns for St. Helena, Prince of Wales Island, Macao (in China), and Fort Marlborough (Java). Returns are still received regularly from India, and certificates from them are constantly in request, since, in the absence of any compulsory system of notification of births and

deaths, these ecclesiastical registrations are generally the only proofs available for legal purposes. Of the returns of baptisms, a specimen is here presented, which records the baptism of Sir George Birdwood at Belgaum on 29th January, 1833. It will be noticed that the date of birth is given, and that to-morrow will be its ninety-first anniversary. For an example of the returns of weddings, I have chosen the page containing the entry of the marriage of Warren Hastings with the divorced wife of Baron Imhoff at Calcutta on 8th August, 1777. It will be seen that the bride gave her maiden name. Dr. Busteed says that the wedding took place "most probably very quietly and in a private house." On the same page, at the top, is the record of the marriage of George Francis Grand to Mademoiselle Werlée, which was solemnized in the house of Thomas Motte. The Rev. William Johnson officiated, as he did at Hastings's wedding. Mrs. Grand's speedy entanglement with Philip Francis, and her marriage years afterwards to Prince Talleyrand, are too well known to need more than a passing allusion.

Owing to the fact that in early days the services of a clergyman were seldom available except in the presidency towns, baptisms and marriages were often celebrated by laymen holding official positions, whether civil or military. The practice was analogous to that which still obtains of British Consuls in foreign countries conducting marriages between British subjects. The validity of such non-ecclesiastical marriages in India was sometimes questioned, but it was generally held that the practice was covered by the powers granted to the Company. It gradually came to an end when the ecclesiastical establishments were increased in the early part of the nineteenth century.

As regards burials, I reproduce a page from the St. Helena returns, recording the interment on 9th May, 1821, of "Napoleon Buonaparte, late Emperor of France." The corresponding record of his death in the St. Helena Consultations is: "Saturday, the 5th, died General Napoleon Buonaparte." The spelling of the surname in both instances recalls the fact that the Allied Powers, to emphasize Napoleon's Corsican origin, insisted on retaining the original spelling, though he himself had long ago adopted a form that looked more French.

For purposes of family history the papers relating to appointments in the Company's services are often of great importance. An essential preliminary was to obtain a nomination from a Director; but the candidate was then required to make a formal application to the Court, accompanied by evidence of the date of birth and other particulars. Here is a specimen of such an application, namely, that submitted by Warren Hastings in 1749 for a writership. With this were forwarded a copy of the record of his baptism and a certificate that he had "gone through a regular course of merchants' accounts" under the supervision of Mr. Thomas Smith, of Christ's Hospital. Hastings's school—Westminster—of course did not profess to instruct its pupils in such mysteries; but it may perhaps take credit for the excellent penmanship of the application.

In the parallel series of applications for military appointments we may select the one sent in by the late Lord Roberts, in 1849. This is on a printed form, only the upper part of which has been reproduced. On the lower part of the page is the nomination, which was made by Major-General Caulfield, at the instance of the candidate's father, General Abraham Roberts. By that date, of course, the application was really for admission to the Company's Military Seminary at Addiscombe.

Of all the officials of the Company's home service the best known is Charles Lamb, a sketch portrait of whom, drawn and etched by his friend and fellow clerk, James Brook Pulham, is next shown. Lamb wrote of it: "'Tis a little sixpenny thing, too like by half, in which the draughtsman has done his best to avoid flattery." The costume was, no doubt, that in which Lamb performed his daily duties at the East India House. The "massy tomes" in which he day by day recorded transactions in tea, cotton goods, and indigo—"more MSS. in folio," he said, "than ever Aquinas wrote, and full as useful"—were long since sent to the papermaker with the Company's other commercial records; and to-day we have little at the India Office directly connected with Lamb. His portrait by Henry Meyer—by many considered to be the best extant—hangs in the room of the Under Secretary of State; the Accountant-General's department cherishes a book of interest tables in which he inserted three mock reviews, alluding to the great interest of the work and the way in which

that interest "rises to the end;" but all that the Record Department can show (besides the references to him in the Court Minutes) is four security bonds bearing his signature. The Directors were men of business, and every clerk who had to deal with money or keep accounts was required to furnish security; while, if a surety died, a fresh bond had to be executed. Here is a facsimile of the first bond signed by Lamb, in which he and his securities agreed to forfeit £500 of lawful money of Great Britain, in the event of any delinquency on his part. His two sureties on this occasion were his father, John Lamb, and Peter Peirson, of whom he gave a sketch in his essay on the Old Benchers of the Inner Temple.

Our last slide shows the earliest known marine insurance policy, dated in 1657 and now preserved among the Java Records at the India Office. The policy is for the sum of £400, insured on the return cargo of the *Three Brothers*, which had sailed two years previously on a voyage to Bantam and Macassar. The document is of great importance in the history of marine insurance, and it is interesting to note that the main provisions are identical with those contained in a Lloyd's policy of the present day. Until a couple of years ago it was believed that a policy of 1681, preserved at Lloyd's, was the oldest in existence, and the discovery that the India Office possessed a much earlier one aroused considerable interest in marine insurance circles in London, Liverpool and New York. We have, therefore, in this document at once an instance of the richness of the India Office records, and a suggestion that still further discoveries will be made whenever this vast mass of documents is thoroughly explored.

In conclusion, I may point out that, although this afternoon the illustrations chosen have been those considered likely to interest an English audience, the archives of the India Office, and the related collections in India, are as important for Indian as for British history. For three centuries the two countries have been acting and reacting upon each other, to their mutual benefit, and present-day India is largely the outcome of those relations. The study of the steps by which the position of to-day has been reached is of interest alike to India and to Britain, and it is a task to which the scholars of both countries can contribute. This fact is now fully recognised by Indian historians, and the British-Indian archives are being increasingly utilised by them, as well as by students of our own race. I am confident that Sir George Birdwood, whose affection embraced alike the land of his birth and the land of his fathers, would have asked no better reward for his labours upon the archives of the Honourable East India Company than that they should in the manner indicated form a fresh and durable link between the two countries.

DISCUSSION.

THE CHAIRMAN (Sir Charles S. Bayley), in moving a very hearty vote of thanks to Mr. Foster for his most interesting and valuable lecture, regretted that it was not in his power to do so in the more fitting and eloquent language which Lord Peel would certainly have employed. It had been his privilege to listen to all of the five lectures which had been delivered since the Royal Society of Arts had resolved to found an annual lecture in memory of the late Sir George Birdwood. On each occasion care had been taken to ensure that the lecture should deal with a subject in which Sir George Birdwood had been interested, and this had been no difficult task for, as all knew, Sir George loved India and everything connected with it, and there were few Indian subjects which he had not studied. Many Anglo-Indians (the speaker used the word in its old sense) could have said, and many could still say, with truth "*Anglo-Indianus sum, indici nihil a me alienum puto*," but none could ever have said it with greater truth or with a fuller meaning than Sir George Birdwood. Neither had it been difficult to find worthy lecturers. Sir Valentine Chirol, Sir Edward Grigg, Sir Thomas Arnold, and Sir John Marshall had all dealt in a masterly way with their very varied subjects, and the Royal Society of Arts and the public owed them a very real debt of gratitude. All would, however, agree that the subject of Mr. Foster's discourse was one of which Sir George Birdwood would have heartily approved and that he would equally heartily have commended the choice of Mr. Foster to handle it. Mr. Foster had described Sir George Birdwood's successful efforts to prevent the destruction of the East India Company's records, and to secure their proper classification and investigation. In this work Mr. Foster had done most valuable service, and he had that day delivered a discourse which showed how worthy he was of a place on the honoured roll of Birdwood Memorial Lecturers. He had also earned the gratitude of his hearers not only by telling them about the treasures of the Record Room but by showing what many of the most interesting were like. The records themselves were often very human and it was interesting to be told that in anticipation of Inchcape Commissions, axes, and things of that sort, the Directors of the East India Company had had a real regard for economy which had led them to use smaller ships rather than incur

the charge of carrying a chaplain. He could not help wondering, as Mr. Foster had been telling them about that, whether there had not perhaps been a little touch of that superstition at work which had obtained amongst sailors until recently, and which possibly still obtained, namely, that the presence on board ship of a "sky pilot" was not conducive to safety. He remembered an instance of that many years ago. He had started from India, and the morning after sailing was beautifully fine. He had made some remark about it to the quartermaster, who had replied with great gravity "Yes, it is fine, but we have too many parsons on board." He had not thought about that remark again until the ship got in the Bay, where they had the most atrocious weather and had to lay to for two nights. In the midst of the storm he came across the quartermaster, who in a most solemn tone of voice said "I told you I mistrusted them parsons." He just wondered whether that same feeling, unjustifiable though it was, had obtained in those remote days.

One of the most interesting slides to him had been that of the letter from Lord Clive and the picture of Lord Clive. The pride of the speaker's family in its connexion with Clive had always been very great. Lord Clive's father, Mr. Richard Clive, had married a Miss Gaskell, whose sister was the wife of his (the speaker's) great-grandfather, and for some reason or other Robert Clive had been sent when a boy of about eight to live with his Bayley relatives in Manchester and had remained there till shortly before he went out to India. Sir Steuart Bayley possessed a letter written by Mr. Daniel Bayley to Mr. Richard Clive, which read as follows :—

"Respected and dear Sir.......... I hope I have made a little for the conquest over Bob, and that he regards me in some degree as well as his aunt Bay. He has just had a fine suit of new clothes, and promises by his reformation to deserve them. I am satisfied that his fighting (to which he is out of measure addicted) gives his temper a fierceness and imperiousness that he flies out upon every trifling occasion. For this reason I do what I can to suppress the hero that I may help forward the more valuable qualities of meekness, benevolence and patience. I assure you, Sir, it is a matter of concern to us as it is of importance to himself that he may be a good and virtuous man, to which no care of ours shall be wanting. I am, with all respect, your most obliged friend and servant, Daniel Bayley."

Mr. Bayley's sentiments were laudable and natural to a man of his peaceful disposition, but no Englishman, and indeed no Indian who had his country's true welfare at heart, could fail to rejoice that Providence in its wisdom had willed otherwise, and had decreed that Clive's "fierceness and imperiousness" had turned into bravery and courage and readiness to fight for the right, which had been the foundation of the Indian Empire, and had redounded to the welfare of England, India, and of the world.

Sir Edward M. Cook, C.S.I., C.I.E., I.C.S., in seconding the motion, said he felt it was in some measure a presumption on his part to do so, partly because he was still a school boy when Mr. Foster had already made his reputation as an authority on Indian history, and partly because he belonged to a generation of Indian officials that had, he feared, fallen very far behind their predecessors in the matter of the study of Oriental languages and history. Whether that was entirely their fault or not, he could not say. They could only hope that succeeding generations of officials, having probably less heavy responsibilities, would be able to repair the omissions of the present generation. Whatever might might be the omissions of the present generation of Indian officials in that matter, he could assure the audience that those in India had at any rate a very keen appreciation of the work that students such as Mr. Foster were carrying on and he knew from his own experience the enormous help that students of both races who came to this country to prosecute their studies always received from Mr. Foster and his Department.

The motion was carried unanimously and the meeting terminated.

NOTES ON BOOKS.

The Tomb Of Tut-Ankh-Amen. By Howard Carter and A. C. Mace. Vol. 1. London: Cassell and Company, Ltd. 31*s*. 6*d*. net.

Eighteen months ago how many people in this country or any where else knew the name of Tut-Ankh-Amen? The number of those who can pronounce it correctly may still be strictly limited, but the startling discovery of his Tomb, revealing a wonderful wealth of artistic treasures well over three thousand years old, struck the imagination even of the man in the street, and made the name of the Egyptian King as familiar as that of Georges Carpentier or the Derby winner. Day after day *The Times* devoted columns to the description of the treasures which the tomb was yielding up, and whole pages to photographs of them. Probably no antiquarian discovery has ever made such a popular stir as that of the late Earl of Carnarvon and Mr. Howard Carter.

The story of the find, then, is still fresh in one's memory; but it is satisfactory to have it set down in permanent book form by one of the chief actors in the drama. The present volume is the first. It opens with an account of Tut-Ankh-Amen and his Queen, and proceeds, after a general description of the Valley of the Tombs, to tell of the great find, the preliminary investigations, the appearance of the Ante-Chamber, the work in the laboratory, and the opening of the inner-sealed doorway. The work of investigating the contents of the innermost chamber is at the present moment proceeding, and will probably occupy the whole of this season, if not longer. It is hoped that further and still more interesting objects will be found here, and their description will form the subjec of Volume II. This will

naturally be more of a scientific record than the first volume, which is written in a somewhat popular style.

An introduction is contributed by Lady Burghclere who gives a very charming biographical account of her brother, the late Earl of Carnarvon. A great sportsman, in love with travel and adventure, it would seem that his tastes were turned towards Egyptology by a serious motor accident which made it impossible for him to follow the very strenuous pursuits in which he had formerly delighted.

A word of praise is due to the publishers for the general get-up of the book. Printing and paper are excellent, and the numerous illustrations are admirably reproduced. Very many of these will be familiar to readers of the book, as they have already been published in many newspapers, but naturally the reproductions in the book are very different from those which appeared in daily and weekly journals.

SOURCES OF SUPPLY OF MANGROVE BARK.

Mangrove bark constitutes one of the world's most important tannin assets because of its great abundance, wide distribution, rapid growth, and comparatively low cost. With a constantly growing market for leather, and a consequent need for ready supplies of tannin, there seems no reason to doubt an early awakening to the economic possibilities of the vast jungles of mangrove that await development along the tropical foreshores of the Eastern and Western Hemispheres. A greater exploitation than hitherto of this most valuable source of tannin, together with the development of new regions of production, would afford effective relief in future demands for tannin.

The following particulars regarding sources of supply of mangrove bark and the manufacture of extract in the principal countries producing the bark has been collated and published by the Research Division of the United States Department of Commerce :—

The mangrove extract of commerce is obtained from the barks of trees belonging to the family Rhizophoraceæ. Of these, the one special to the American Tropics is the Rhizophora mangle, popularly known as red mangle, while several species abound in the eastern Tropics, where the areas under mangrove are far more extensive. All parts of the mangrove tree, but more especially the bark and leaves, contain tannin. The percentage of tannin in the bark ranges from 5 to 48 per cent., the content increasing with the size and age of the tree ; the average of commercial grades is about 35 per cent. If the bark is exposed to moisture after collection, a considerable loss in tannin is sustained, hence the necessity for drying under cover during the rainy season. When dried the bark is roughly broken into small pieces and placed in bags or packed in small bales, sometimes under pressure, for export.

The mangrove extends as far north and south as the twenty-ninth parallel. It forms a dense growth in patches on the low coasts of all tropical islands. In the United States it occurs along the shores of southern Florida, at the mouth of the Mississippi River, and on the coast of Texas. The low coast marshes of Porto Rico produce abundant supplies of mangrove, but, while used locally for both its wood and its bark, the industry has not yet reached an export basis. Mangrove barks constitute the greatest single source of tannin in the Philippines. Analyses prove Philippine barks as rich in tannin content as those used in the cutch factories of Borneo ; in fact, the same species of mangrove are common to both regions. Notwithstanding the abundance of mangrove in the Philippines, there are no cutch factories, although the swamp area of one bay in Mindanao covers 25,000 hectares, which, estimating 25 tons of bark to the hectare, would yield a total of 625,000 tons of bark. With a 20-year rotation this should be sufficient to supply a large factory indefinitely. Foreign markets for the bark have not been developed.

Prior to the war Germany was active in the exploitation of mangrove bark as a tanning agent. Its main source of supply was East Africa, whose barks seem to be richer in tannin than those of the East Indies. In the former German protectorate the bark was most carefully stripped from the living tree (stripped trees are said to renew their bark in four to six months) under the supervision of the forest department and prepared for export. The export of bark containing less than 45 per cent. of tannin was prohibited.

Madagascar exported 21,938 metric tons of mangrove bark in 1913, the greater proportion of which was taken by Germany. In 1917 its exports totalled only 3,410 tons. This decrease was due largely to lack of transportation facilities. Postwar exports, however, have not yet reached the 1913 level. While West Africa has extensive mangrove swamps, no serious attempt at bark collection has yet been made, except in British West Africa, where the industry is well established. Some years ago bark collection was started in Senegal by a French company, which allowed the trees to be cut down without making provisions for replanting, with the result that rapid erosion of the foreshore took place. The Government prohibited further exploitation by that company. Stocks of mangrove bark in Burma were practically exhausted in 1919. The problem of working important areas of mangroves in the Andaman Islands is receiving the serious consideration of the authorities.

The manufacture of extract in the principal countries producing mangrove bark has not been as effectively developed as that of quebracho extract in Argentina and Paraguay. If, however, the industry could be promoted in those countries possessing abundant supplies of mangrove, not only the poorer grades of bark could be utilized but also the leaves, which contain considerable

tannin. The leaves are rarely exported, owing to deterioration during transportation. To avoid certain unfavourable chemical changes, which the bark undergoes within 48 hours after cutting, it is considered essential to work it up as soon as possible. For this reason the factory should be located in or near the mangrove area. It requires 4 to 6 tons of bark to produce 2 or 2½ tons of cutch. The elimination of waste, greater convenience for shipment, and saving in transportation costs should make for further expansion in this industry.

Mangrove extract is also called mangrove cutch, because of a similarity of properties to the cutch derived from the Acacia catechu of India and Burma. A constant supply of the latter could not be relied on, and when the mangrove product came into the market it superseded the Indian cutch to such an extent that the term is now mainly applied to mangrove extract.

In Dutch and British Borneo the manufacture of extract has become an industry of great importance. The principal factories are located at Pontianak, Rejang, Brunei, Kudat, and Sandakan. The latter two are under Scotch control. In 1919 the Netherlands Indies exported 3,546 metric tons of mangrove cutch, against 805 tons in 1918. In 1920 and 1921 the exports fell to 1,598 and 830 tons respectively. The bulk of these exports was the output of the Pontianak factory.

Exports of mangrove cutch from the Straits Settlements aggregated 2,481 tons in 1920, an increase of only 106 tons over 1919. The figures for 1921, however, showed a marked increase over the two previous years, amounting to 3,602 metric tons. Straits Settlements exports are largely re-exports having their origin in Borneo.

The extraction of tannin from mangrove bark is a well organised industry in East Africa. The interest which that region takes in its expansion is manifested in two recent concessions granted for the exploitation of the bark in which it was obligatory on the concessionaires to inaugurate tannin extract factories within certain specified periods of time.

Mangrove extract is imported in large blocks of a reddish brown colour, and has a tannin content ranging from 48 to 72 per cent. according to country of origin. The higher grades come from East Africa and Borneo. Used alone this extract yields a good, pliant, workable leather, but of undesirable colour. To modify this objection German tanners blend it with myrabolans, valonia, sumac and similar materials; and British tanners with pine, oak and mimosa barks. In France the favourite blend is Mangrove bark 30 per cent., hemlock bark 40 per cent., oak bark 20 per cent., and mimosa bark 10 per cent. The French blend yields a superior grade of leather, with an excellent colour for general use.

GENERAL NOTES.

Chinese Cotton Mills.—The Chinese Government Bureau of Economic Information has published a sheet of tabulated information respecting cotton mills in China. One of its most important features is the column dealing with the motive power employed. Of the 112 Mills in the list, 37 use electricity either wholly or in part, the remainder being apparently provided with steam plant. Practically all the establishments in Shanghai and Woosung—numbering 24—are electrified, and it will thus be seen that the opportunities for trade in this direction lie mainly in other parts of the Republic. Five British-owned mills are listed. These are all in Shanghai, but the motive power employed is not stated. Information in this respect is also lacking in the cases of 32 Japanese owned factories, mainly in Shanghai and Tsingtau. Apart from these, however, there is a number of establishments with from 3,000 to 90,000 spindles—average about 20,000 in which steam power is still employed.

Cotton in Spain.—Spain is growing more and more cotton in the southern provinces in order to counteract the importation of cotton from America, and, according to the *Indian Textile Journal*, the industry is changing from a purely home industry to an export industry, with all the possibilities of indefinite expansion implied in this change. The industry, located almost entirely in Catalonia—which is the most promising hydro-electric centre in Spain—employs at present over 100,000 workers, and exports considerable quantities of the coarser types of cotton goods to the Spanish colonies and South America. Hydro-electric power on a large scale is being introduced and this will undoubtedly lead to the introduction of electrical driving into the cotton mills, and open thereby a new market of very great importance in the future.

Successful Treatment of Canadian Tar Sands.—It is claimed that methods have been perfected by which commercial products can be obtained from the Athabaska tar sands found in the Province of Alberta, Canada. According to *Commerce Reports*, a plant has been erected at Waterways, on the Great Western Railway, where experiments have been successfully conducted. Two processes are said to have been developed, one for the separating of oils, and the other for extracting asphalt. The crude oil obtained by the first method is of 19.3 Baumé gravity, while the asphalt extracted gives a large yield of the merchantable product, ranging from 15 to 25 per cent. of the raw sand. Owing to the small percentage of the lighter constituents and the presence of sulphur, the crude oil is not the most satisfactory for producing gasoline or kerosene, but the lubricating oil stands an extra low cold test, and is an excellent product for use in cold climates.

Macedonian Opium.—In his report on the Industrial and Economic Situation in Greece, Mr. R. F. Duke, Commercial Secretary at the British

Legation in Athens, calls attention to the fact that the quality of Macedonian opium is excellent on account of the superior dexterity of the labourers engaged in its collection. In making incisions in the poppy head, especial care is taken to avoid cutting beyond the latex into the debris of the pericarp. As a result the Macedonian opium has a fine, light and delicate paste and is remarkably rich in morphine, 15 to 20 per cent. being registered. Anatolian opium usually carries from 9 to 14 per cent. of morphine. The producing districts in Macedonia are :—Veles, Cavalar, Koumano, Istip, Radovitch, Perleps, Strumista in Serbia, 84 per cent. Petrich in Bulgaria, 8 per cent. Kilkis, Serres, Langada in Greece, 8 per cent. The opium crop in 1922 yielded about 500 cases of 150 lbs., whilst an average crop yields 1,000 cases. The countries to which opium is exported are principally the United States of America, Germany and France.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock :—

January 23.—G. Albert Smith, "Cinematography in Natural Colours—further Developments" (with illustrations—scenes from H.R.H. The Prince of Wales's Tour in India).

January 30.—Sir Richard Arthur Surtees Paget, Bt., "The History, Development and Commercial Uses of Fused Silica." Sir Herbert Jackson, K.B.E., F.R.S., will preside.

February 6.—Iyemasa Tokugawa, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

February 13.—H. Maxwell-Lefroy, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle." Sir Aston Webb, K.C.V.O., C.B., P.R.A., will preside.

February 20.—Percival James Burgess, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber."

February 27.—

March 5.—Major-General Sir Fabian Ware, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries."

March 12.—Alan A. Campbell Swinton, F.R.S., late Chairman of the Council, "Recollections of some Notable Scientific Men." (Illustrated by Photographs.)

March 17.—R. L. Robinson, Member of the Forestry Commission, "The Forests and Timber Supply of North America." Lord Lovat, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., will preside.

March 24.—Neal Green, "The Fishing Industry and its By-Products."

Dates to be hereafter announced :—

Sir Lynden Macassey, K.B.E., "London Traffic."

Charles S. Myers, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation."

T. Thorne Baker, "Photography in Industry, Science and Medicine."

Mrs. Arthur McGrath (Rosita Forbes), "The Position of the Arabs in Art and Literature." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Indian Section.

Friday afternoons at 4.30 o'clock :—

January 18.—Colonel H. L. Crosthwait, C.I.E., R.E., retd., late Superintendent, Survey of India, "The Survey of India." Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., Rector, Imperial College of Science and Technology, will preside.

February 15.—Sir Richard M. Dane, K.C.I.E., Commissioner North India, Salt Revenue, 1898-1907; Foreign Chief Inspector, Salt Revenue, China, 1913-18, "Salt Manufacture in India and China."

May 2.—Jocelyn F. Thorpe, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

Bhupendra Nath Basu, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

Dominions and Colonies Section.

Tuesday afternoons at 4.30 o'clock :—

February 5.—F. W. Walker, "The Commercial Future of the Backward Races, with Special Reference to Papua." Sir George R. Le Hunte, G.C.M.G., will preside.

May 27.—C. Gilbert Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

Date to be hereafter announced:—

THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak."

CANTOR LECTURES.

ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." Three Lectures. January 21, 28; February 4.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25, March 3, 10.

COBB LECTURES.

Monday evenings, at 8 o'clock:—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

DR. MANN JUVENILE LECTURES.

(*Special tickets are required for these Lectures.*)

Wednesday afternoons, at 3 o'clock:—

DR. WILLIAM ARHUR BONE, F.R.S., Professor of Chemical Technology, Imperial College of Science and Technology. "Fire and Explosions." Two Lectures, January 2, 9. The Lectures will be fully illustrated with experiments.

MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, "Among the Selkirk Mountains of Canada (with ice-axe and camera)." One Lecture. January 16. The Lecture will be fully illustrated with hand-painted lantern slides.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 7..Chemical Industry, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m.

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m.

Victoria Institute, Central Building, Westminster, S.W., 4.30 p.m. Rev. M. G. Kyle, "The Problem of the Pentateuch from the Standpoint of the Archæologist."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Informal Meeting.) Mr. J. W. Beauchamp, "Troubles Experienced with Domestic Electric Appliances."

Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C., 5.30 p.m. Mr. E. M. Lewis, "Inland Waterways"

TUESDAY, JANUARY 8..Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C.. 5.30 p.m. 1. Mr. J. Kewley, "The Crude Oil of Sarawak." 2. Dr. A. E. Dunstan, "The Crude Oil of Maidan-i-Naftan."

Transport, Institute of, at the Institute of Electrical Engineers, Savoy Place, Victoria Embankment, W.C., 5.30 p.m. (Graduate Section.) Mr. W. C. Collins, "The Organisation of a Terminal Station."

Child Study Society, University College, Gower Street, W.C., 5 p.m. Conference of Educational Association. Miss Elsie Fogerty, "The Diploma in Dramatic Art."

Metals, Institute of (Local Sections), Chamber of Commerce, New Street, Birmingham, 7 p.m. Mr. O. Smalley, "Nickel Brasses." (N.E. Coast Section), Armstrong College, Newcastle-on-Tyne, 7.30 p.m. Mr. H. M. Duncan, "The Action of Molten Brass on Nickel Steel."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Mr. R. Williams, "More Milestones of African Civilisation and some Problems."

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Mechanical Engineers, Institution of (South Wales Branch), Chamber of Commerce, Swansea, 6 p.m. Sir James H. R. Kennel "Modern Developments in Steam Raising."

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. R. G. Reid, "Modern Refrigerating Machines."

Royal Institution, Albemarle Street, W., 3 p.m. (Juvenile Lecture.) Prof. Sir W. Bragg, "Concerning the Nature of Things." (Lecture VI.)

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Mr. de Barri Crawshay, 1. "Eoliths found *in situ* at South Ash." 2. "Azilizn-Tardenoisian Flint Industry in Mesopotamia (*Exhibit*)."

WEDNESDAY, JANUARY 9..Automobile Engineers, Institution of, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., 6.30 p.m.

Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. 1. Prof. S. H. Reynolds and Dr. E. Greenly, "The Geological Structure of the Clevedon-Portishead Area (Somerset)." 2. Dr. F. S. Wallis, "The Avonian of the Tyrherington-Tortworth-Wickwar Ridge (Gloucestershire).." 3. Miss A. E. Bamber, "The Avonian of the Western Mendips, from the Cheddar-Valley Railway to the Sea, West of Brean Down."

THURSDAY, JANUARY 10..Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Dr. Aitchison and Mr. North, "Materials from the Aeronautical Point of View."

Metals, Institute of, at the Institute of Marine Engineers, 85, The Minories, E., 8 p.m. Mr. W. T. Griffiths, "X-Rays and Metallurgy."

Mechanical Engineers, Institution of (Local Branch), Royal Technical College, Glasgow, 7.30 p.m. Prof. J. Muir, "Radiation and Atomic Structure."

Linnean Society, Burlington House, Piccadilly, W., 5 p.m. 1. Mr. A. J. Wilmott, "Some further additions to the British Flora." 2. Mrs. Henshaw, "Plant Life in British Columbia" (lantern slides). 3. Mr. R. H. Burne, "Exhibition of Specimens of the Carotid Arteries of *Lamna* and other Sharks."

Historical Society, 22, Russell Square, W.C., 5 p.m. Mdme J. Lubimenko, "The Anglo-Dutch Commercial Struggle in the 17th Century."

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. T. Peters, "Italy."

FRIDAY, JANUARY 11..London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Sir Theodore Chambers, "Satellite Towns."

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W., 8 p.m.

Astronomical Society, Burlington House, Piccadilly, W. 5 p.m.

Timber Trade Lectures, London Chamber of Commerce, Oxford Court, Cannon Street, E.C. Mr. F. Tiffany, "Principles and Ethics of Business."

Metals, Institute of, at the Albany Hotel, Fargate, Sheffield, 7.45 p.m. (Conjoint Meeting with the Institute of British Foundrymen.) Mr. F. H. Hurren, "Influence of Casting Temperature on the Physical Properties of Metals."

Journal of the Royal Society of Arts.

No. 3,712. VOL. LXXII.

FRIDAY, JANUARY 11, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

FUND FOR PURCHASING AND RENOVATING THE SOCIETY'S HOUSE.

NINTH LIST.*

	£	s.	d.
Amount previously acknowledged	43,033	17	4
The Gas Light & Coke Co. ..	200	0	0
George Percival Baker, Esq...	10	0	0
Professor John Uri Lloyd, Ph.D., LL.D.	8	2	0
Harry Houlton Vivian, Esq., J.P.	5	5	0
Rajah Bahadur Naba Kishore Chandra Singh	5	0	0
The late Brigadier-General A. C. Bailward (second donation)	3	0	0
Denis Ripley Broadbent, Esq., A.M.I.E.E., A.M.I.M.E. (second donation) ..	2	2	0
Inayatullah Khan, Esq., M.A.	2	0	0
Francis Wright, Esq. ..	2	0	0
George Andrew Matzinger, Esq.	1	1	0
Samuel Athim, Esq., Assoc. M.Inst.C.E.	1	0	0
Rev. E. O'Neill		10	6
	£43,273	17	10

The above list includes all subscriptions received up to January 1st. Further lists will be published in the *Journal* from time to time.

Fellows of the Society are reminded that the amount aimed at by the Council is £50,000, which will cover the cost of renovating and decorating the House.

*The eight former lists were published in the *Journals* of December 2nd, 1921, January 13th, February 24th, May 5th, July 14th, and November 17th, 1922, and February 9th, and July 20th, 1923.

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 16th, at 3 p.m. (Mann Juvenile Lecture.) MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, "Among the Selkirk Mountains of Canada (with ice-axe and camera)."

A few tickets for this lecture are still left, and these will be issued to Fellows who apply for them at once.

INDIAN SECTION.

FRIDAY, JANUARY 4th, 1923; GENERAL SIR EDMUND BARROW, G.C.B., G.C.S.I., Member of the Council of India, in the Chair.

A paper on "The Indian Ordnance Factories and Indian Industries" was read by BRIGADIER-GENERAL H. A. YOUNG, C.I.E., C.B.E., late R.A., Director of Ordnance Factories, India, 1917-21.

The paper and discussion will be published in a subsequent number of the *Journal.*

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MANN JUVENILE LECTURE.

The third series of Juvenile Lectures, under the Dr. Mann Trust, was commenced on Wednesday afternoon, January 2nd, by Professor William Arthur Bone, F.R.S., the subject being "Fire and Explosions." The chair was taken by Mr. Alan A. Campbell Swinton, F.R.S., a Vice-President of the Society.

Professor Bone, in his opening remarks related the story of the Norse God, Balder the Beautiful, who, after being, as the gods thought, rendered invulnerable, was slain by Hoder by means of a dart made of mistletoe, the only thing in creation which had not taken an oath to do him no harm. He referred to the veneration of our remote ancestors for the oak, by means of which they kindled a fire, and for the mistletoe which they regarded as the seed of fire and the source of life and vitality. He traced

the association of this story with the present day custom of cutting mistletoe and burning the yule log at Christmastide. Fire had always been surrounded by mystery from the very earliest times, and even in Shakespeare's day, he said, it was considered one of the mysterious elements of which the world was composed.

The lecturer then dealt with the researches and discoveries of Jean Rey (1630) relating to the calcination of metals; of Robert Boyle, the father of modern chemistry, and inventor of what we now know as the air pump; of Robert Hooke, the inventor of the marine barometer, who was associated with Boyle in the production of the air pump; of John Mayow, who actually made oxygen in 1674, nearly a century before it was supposed to have been discovered by Priestley and Scheele. Professor Bone also discussed Stahl's phlogiston theory—the hypothetical principle of fire or inflammability regarded as a material substance. This theory produced fruitful results and held sway for a century. He then dealt with Priestley's and Scheele's discoveries, the former of whom had given us that great boon to humanity known as "laughing gas" which was greatly used by dentists. In 1754 Priestley obtained what he termed dephlogisticated air, afterwards named oxygen by Lavoisier, the discovery of which formed the germ of the modern science of chemistry. Priestley also showed us how to make soda water, whilst Scheele, the distinguished Swedish chemist, discovered chlorine, prussic acid, tartaric acid and citric acid, and was the first to collect ammonia. The researches of Henry Cavendish, who discovered that water was formed when hydrogen was burnt in air, were also referred to, as well as those of the celebrated French chemist, Lavoisier, on combustion.

The lecture was fully illustrated by a most interesting series of experiments, including the working of a Geryk air pump; Mayow's candle experiments; the heating of phosphorus *in vacuo* and its burning in a bell jar; the burning of a piece of magnesium ribbon to show that the residual ashes weighed more than the original piece of ribbon; explosive soap bubbles composed of oxygen and hydrogen; and the lecture concluded by a demonstration of the burning of barium and strontium chlorates in an atmosphere of hydrogen or coal gas, and of coal gas being burnt in air and of air being burnt in coal gas.

PROCEEDINGS OF THE SOCIETY.

SIXTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 12TH, 1923.

SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., a Vice-President of the Society, in the Chair.

The paper read was:—

PRESERVATION OF ANCIENT MONUMENTS AND HISTORIC BUILDINGS.

By SIR FRANK BAINES, C.V.O., C.B.E., Director of Works, H.M. Office of Works.

I do not think it is necessary before this audience to attempt to state a case illustrating the value of preserving our Ancient Monuments and Historic Buildings. They are a part of the culture and history of the British people and I propose to take it for granted that we are in agreement as to the essential need of their retention and preservation. These buildings are a signal record of a previous social tradition which brings down to our mechanical and competitive age a suggestion of a saner spirit and finer method of life. It has been well said that "the present is charged with the past and is big with the future:" and that the more perfect and ordered the record of tradition is, the more the race of man becomes as one; living, learning and advancing. It is, therefore, the more interesting to be able to record that the value given to buildings and historic monuments at the present time would appear to be increasing year by year. This interest and sense of value is not spent upon works involving a soulless repetition of ancient detail and models, an archaistic idolatry of restoration, but is a due and effective renewal of the material and spirit of a past time and its usages, which attempts to give a clear historical synthesis involving a re-orientation of the study of tradition.

Before discussing the question in detail, I should like to suggest to you first of all what we mean when we use the word "preservation." Clearly we do not mean restoration, or replacement of what is gone; we do not mean renovation or renewal. These latter phrases are dangerous phrases; they are sometimes used by people—entirely conservative in their sympathies—as though they were interchangeable with the term "preservation." Of course, they are not interchangeable; and

it is necessary to define the word "preservation" as meaning a method involving the retention of the building or monument in a sound static condition, without any material addition thereto or subtraction therefrom, so that it can be handed down to futurity with all the evidences of its character and age unimpaired. Restoration may be a word justifiably describing *a* method of preservation, but I wish to make it clear that that method is not the method advocated here.

There are two main advantages in rigidly adhering to some general interpretation of the term "preservation" such as I have suggested. One is that it is incumbent upon the technician dealing with the work of preservation to sink his individuality to the uttermost and merely to throw up the distinctive character and individuality of the work of the mediæval constructor. You will, doubtless, agree that it is of primary importance that the work of the mediæval constructor should be preserved without any alteration whatsoever, if that is statically possible; and that in no instance should repetition work involving the construction of even technically accurate and perfect replicas of a feature of old work, however beautiful, be permitted.

The second main advantage I have in mind is that the methods of preservation advocated here involve vastly less expense than the methods of restoration, renovation or replacement. Many instances could be given of this, and in these difficult times of financial stringency the virtue is twofold—one, in the limitation of Government expenditure; and two, that the limitation directly preserves unimpaired and in its original form and character, the monument or building being dealt with. Indeed, it should be an invariable rule to spend as little as possible upon the work of preservation of a building or monument. There is, however, need for further definition. The work of preservation should aim at some finality so that repeated returns to the structure need not be made; restless, continual and piece-meal patching of a monument is rightly provocative of criticism. Indeed, with many great structures such a policy would be extravagant in the extreme as the question of scaffolding alone is a prohibitive item of cost.

As to the terms "Ancient Monument" and "Historic Building." The first has been defined as a structure under or above ground which possesses value as a historic or artistic monument. It may be a movable or immovable object handed down from a previous age, which as a structure or erection has specific public interest by reason of its historic, architectural, traditional, archæological or artistic interest.

The term "Historic Building" could clearly be comprehended as coming within the definition of "Ancient Monument," but the expression generally is used to denote a building which still partly retains its character as a building for use, although it may or may not be in use as originally designed. Historic buildings in use must be subject to some elasticity of treatment, more so than the buildings which are not in use as structures to afford cover, or which are not functioning for any purpose as occupied buildings.

The treatment of ancient monuments in the past may be referred to under three headings—the first, regrettably represented by the word demolition; the second, by the word restoration; and the third, by the word preservation.

The first phase clearly can be said to date from the dawn of history and to have been arrested in part only so late as the early years of the 19th century.

The restoration phase approximates roughly with the 19th century, but the effects of this phase are, of course, in evidence to-day.

The true conception of preservation is quite a modern conception, and its early and tentative proposals as a consistent scheme of treatment hardly go further back than the period within the memory of living man.

Demolition applied to buildings which at the time would surely be called historic buildings, and which to-day we should look upon with the utmost reverence and respect, was universal amongst Greek, Roman and mediæval builders.

The expression of national greatness and the rivalry between local communities in the erection of monuments more magnificent than those erected by their predecessors, was always in the past considered a sufficient excuse for the total destruction of earlier work, nor would it appear that any sense of guilt existed when this destruction was undertaken.

Even the great Masters of the Renaissance in Italy, who founded much of their work upon the work of the ancient builders of

the past, appeared to be quite content to destroy and to utilize the material with which these older monuments were built, for their own erections. Although there is a record that as far back as the 14th century the City Statutes of Rome banned under heavy penalty the defacing of the vestiges of the ancient city, these Statutes would appear to have been largely disregarded.

The growth of archæological research in Italy in the 15th and 16th centuries may well be said to mark the starting point of a more intelligent appreciation of the works of the past. Practical results did not follow as yet, and when they did follow, the practical work was rather in the nature of restoration than preservation as previously defined.

Even when archæology was studied scientifically, Lord Elgin would seem to have had no compunction in removing the treasures of Greece to this country, while as late as 1877 Cleopatra's Needle was brought to this country and set up by the Thames to decay under the acid-laden atmosphere of modern London.

Without any apparent discrimination the Gothic architecture of France was robbed of its ancient fittings; and similar destruction was being wrought in this country at Salisbury and elsewhere. Attempts were made to classicise the Choir of Chartres Cathedral and St. Méry in Paris, and although the drawings of ancient work published by antiquaries were painstaking to a degree, many of them were found to be comparatively valueless as historical records.

Towards the close of the 18th century and in the beginning of the 19th century, the writings of Sir Walter Scott and the drawings of Samuel Prout assisted in spreading interest in the mediæval architecture in this country—assisted, of course, by the Oxford movement—with the unfortunate result that in many cases the work of a later period, even then of some historic value, was ruthlessly swept away to give place to lifeless replicas of mediæval work and handicraft.

On the Continent there was an awakening of interest in ancient buildings, as is indicated by Government action which took place in several countries from the 17th century onward; and the Papal States and the Provinces of Tuscany, Lucca, etc., now comprising the Kingdom of Italy, issued edicts, aiming at the preservation of historic work. These edicts were consolidated in 1902 and further legislation has taken effect as recently as 1920, while it is interesting to record that the Greeks took immediate advantage of their independence to stop the spoliation of the incomparable monuments for which their country is famous, by the passing of an Act in 1834.

In Belgium, church property was safeguarded by a royal decree in 1824, supplemented in 1835.

In Germany, regulations for the preservation of its ancient monuments have been framed since 1815, and although they would not appear to have statutory sanction, much respect was shown for their monuments. Indeed, Germany is richer at the present time in mediæval church furniture than any other country of Europe.

Scandinavian countries were in the field as early as the 17th century, aiming at the preservation of their antiquities, while in France the appointment of a General Inspector of Historic Monuments in 1834 was followed by numerous enactments aiming at preservation, although the understanding of that term in France, unfortunately, would appear to be vastly different from the understanding in England.

In Austria, a Royal Central Commission was established about 1864, and in Hungary ancient monuments were placed under protection of the State in 1881.

England, in accordance with her democratic social organisation, appeared to await the expression of public opinion before committing herelf to statutory enactments, and it was not until 1822 that the first Bill dealing with the subject became law. Generally, privately owned monuments and historic buildings in Europe are not under Government control, with exceptions in Italy, Hungary and France. In France, such monuments are not usually scheduled, but compulsory purchase is possible, as is also the case in Denmark and Greece. In Spain and Saxony official pressure is exercised. Switzerland even aids private individuals financially in the upkeep of historic monuments. Sweden and Norway have got so far as to lay down the principle that a monument may be of such an age that it may no longer be held to be private property, while Greece forbids the erection of lime kilns within two miles of classic ruins—for very obvious reasons. This, however, did not prevent the demolition of the old Venetian Tower on the Acropolis

at Athens about 1880. In India, ancient monuments were protected by legislation in 1904, and certain of the States of America have laid down provisions in their laws, for conservation.

Unfortunately, this general awakening of a regard for National Monuments caused an outpuring of money raised voluntarily or by compulsion, which went into the coffers of the would-be conservers; and, as a result, great works were undertaken which aimed not at preservation, but at restoration and renovation and even at the removal of such work existing which did not approximate to pre-existing remains.

Ruskin did, indeed, preach conservation consistently, but even those who agreed in principle with preservation of ancient monuments, appeared to apply in practice the principles of restoration. I could detail at considerable length, if the time at my disposal would allow, a sad list of examples of this practice in France involving a vast expenditure upon work of repetitive re-building. Such instances would extend into pages of matter, illustrating the grievous and heavy losses which have been incurred; partly perhaps as a consequence and a result of the scholarship and knowledge of M. Violett-le-Duc.

In England, as in France, the damage done owing to over-prodigality of expenditure has been serious and irreparable. For example, to give one instance alone, the restoration of Worcester Cathedral between 1857 and 1874, which involved an expenditure of considerably over £100,000, resulted in handing down to us a building that is externally to all intents and purposes a modern structure. There is no record that major structural problems were involved here, but a great deal of money was spent on refacing owing to the character of the red sandstone of which the Cathedral was built. During the first 50 years of Queen Victoria's reign, well over £1,000,000 was spent on 20 of our cathedrals, with results that the judicious can only deplore; many of these buildings are now largely modern, particularly is this so in the cases of Worcester, Chester and Lichfield. The east window of Carlisle and the west window of York Minster, probably the finest examples of flowing tracery in this country, and perhaps in the world, were lost to us; the whole having been renewed in both cases. Need I say again that replicas of ancient work, however perfectly and accurately executed, can have no real historic or archæological value whatever?

Again, long lists of instances could be given of what we have lost in England during the restoration period; the records exist and afford the most painful reading to-day, in the annual reports issued by the Society for the Protection of Ancient Buildings, founded in 1877, to educate the public on the lines of conservation and preservation as opposed to restoration and renovation.

A word of sincere appreciation of the great work carried out by this Society is, I think, called for here. Their aim has been consistent throughout: namely, to enlist the sympathies of the British public in the conservation of every fragment of old work as opposed to repetitive restoration; and if such views are slowly percolating downward to that hypothetical person "the Man in the Street," it is largely due to the fine propaganda work done by this Society.

Now that legislation is taking its hand in dealing with the problem, certain results accrue which, it is claimed, should instruct the public still further in the importance of the principles laid down. Certain classes of ancient monuments, etc., have been protected by Parliament by Acts passed in 1882, 1900 and 1910. These Acts were repealed in part by the Ancient Monuments Consolidation and Amendment Act of 1913, and this Act, though of considerable importance, is strictly limited in scope, providing, as it does, a saving clause for buildings used as dwelling houses, otherwise than by persons employed as caretakers, etc., and excluding also from the definition of the expression "Monument" any ecclesiastical building used for the time being for ecclesiastical purposes. This exclusion in principle rules out all the great English cathedrals, many of the great castles and monastic buildings and nearly every church in this country; which should make it clear that the importance of obtaining agreement to the principles of preservation versus restoration is greater now than ever.

It is desirable to attempt to lay down in some detail how the principles which I have briefly suggested here are interpreted with regard to ancient monuments and historic buildings under the charge of the Crown, and I propose to do so by throwing on the screen certain of the buildings in process of preservation, illustrating the character of the work executed and the way the

principles are interpreted in specific work.

Before doing so, I should like to make it clear that the Departmental organisation under which this work is carried out utilises the Ancient Monuments Advisory Boards appointed for England, Wales and Scotland, and it should be mentioned that our Chairman this evening is a most distinguished member of the English Advisory Board. The archæological and historic aspects of the buildings are further safeguarded by the appointment of a Chief Inspector and Inspectors of Ancient Monuments, who advise the Department on all matters of archæological and historical moment, which arise in connection with the proposed methods of preservation of the buildings. It has often been said that the Ancient Monuments Consolidation Act of 1913 imposes certain restrictions upon the freedom of the private citizen; this is unquestionably true and as a result of such restrictions the practice of the Government in regard to the National Monuments in the charge and ownership of the Crown has been consideraly affected and modified. This point is of material importance, as it is clear that in imposing restrictions upon the private citizen the Government must assume an obligation to set its own house in order and to see that the national monuments under its control are properly administered and preserved.

There are, therefore, two classes of monuments in the charge of the Crown—

(1) Crown monuments and historic buildings often part of the hereditary possesson of the Crown; and

(2) Buildings and monuments transferred to the charge of the Government under the provisions of the 1913 Act.

The first point I wish to bring out is that with regard to the latter class of buildings, they are generally transferred to the Crown suffering from the most distressing neglect and even ill-treatment; all are in a state of general instability and active decay. I propose to give instances of this upon the screen.

The points I wish to bring forward are:—

(1) The tremendous destruction of the buildings due to neglect and decay; and

(2) The enormous growth of ivy, shrubs and trees even, upon the wall heads, which in many cases have rent the masonry asunder for lengths up to 30 feet and for widths up to a maximum of 1ft. 3in. to 1ft. 9in.

This problem of preservation, therefore, in these circumstances is quite a new one, a problem which did not face the mediæval constructor.

The problem may be briefly described as follows:—

To attempt to retain in its existing form a partial structure, when all its original equipoise of thrust and counter thrust has been destroyed by the failure of portions of the building. For example, you may get an arcade standing as detached overloaded columns without any support from the thrust of the original vault and the counter-thrust of the original aisle roof, buttresses, etc. If this arcade stands at such an angle of inclination from the vertical that it is at the moment unstable, the problem is a serious one. Such a problem could be dealt with reasonably simply if it was possible or justifiable to restore the original static condition of the structure. This, however, would involve so much reconstruction and restoration that it must be ruled out of consideration. The problem, therefore, is clearly entirely different from that of the mediæval constructor and also from that which faces the architect and civil engineer of to-day in designing a new structure; and such a problem has to be dealt with entirely on its merits.

Generally, the problems must be faced without any formal or set ideas as to their solution. The first principle laid down is the need to ascertain as clearly as possible the static condition of the structure under all its conditions of decay, incipient and partial failure, actual collapse, etc., and I propose to show upon the screen a plan made of Tintern Abbey which I would describe as a statical or technical survey of the building, showing clearly before any work is done the condition of the structure and the problems which have to be faced.

Tintern Abbey is one of our most interesting and romantic Cistercian Abbeys. The date of the existing work is generally that of the end of the 13th century, when the present church was built to the south and east of the older church. You will see that the north arcade of the nave has fallen, carrying with it the whole of the vault of the nave, leaving the great south arcade standing to a height of 68 feet, existing merely as a series of overstressed, distorted piers, eccentrically loaded and unsupported by any thrust of vault or counter-thrust of aisle roof, etc. The thickness of this

arcade at the top is 5ft. 6in., and the weight carried by each pier is roughly 210 tons. The wall is seriously overhung to the north to the extent of 18in., inducing excessive compressive stress on the north side of the piers and a tensional stress on the south side of the piers. As a result the piers are found to be actually failing under crushing. Many of the stones both of the piers and the caps have been fractured completely through, some of them being in a thoroughly shattered condition.

The original proposal, before the Department undertook the charge of the building, was to take down and rebuild plumb, a great proportion of the arcade above the arches. The Department, however, decided that such a course of action would ruin the amenities of the building and generally the scheme which was undertaken was to relieve the eccentric stress on the north side of the piers, and also to relieve them entirely of stress due to wind pressure. This was done by the institution of a great lattice girder of the N. type anchored into the wall of the south transept and to the wall of the west gable, designed to move under temperature stresses and under slight oscillation of the arcade. It would take more than the time at my disposal to detail the theory underlying the design and erection of this girder, but I wish to make it clear that the scheme was devised to preserve the amenities of the arcade as seen from the nave, which otherwise would have had to be heavily buttressed. To use modern knowledge and experience in obtaining that result would seem to be fully justifiable. It has been sometimes contended that in the preservation of historic buildings only the materials and methods of the mediæval constructor should be used. Such methods could indeed be used, if restoration could be considered and the principle of preservation only, departed from. Then a lime-built masonry structure could be devised which would reinstitute the thrust and counter-thrust of the original building, and perhaps reach a state of statical stability without utilising modern knowledge and the methods of our day.

The loss, however, by following this practice would be enormous. At Tintern it would involve the rebuilding of the whole of the north arcade, the whole of the stone vaults of the nave and aisles, and a practical reconstruction of the Abbey Church. Such a course could only make the judicious grieve; and, indeed, in these days when the complete preservation, without addition, of our historical monuments is the principle which guides us, such a course of action could not be contemplated. Further, the expenditure involved by such a scheme would be vastly greater than could be considered by the Government to-day, and it is clear that when Tintern Abbey is completed, within a very short time, the works of preservation will not be apparent, and in a few years the hand of time will place its softening and enriching imprint upon the building once more, when the instructed public can view this wonderful monument in a form showing its original features without any unwarrantable disturbances or additions thereto.

There were other problems at Tintern which I will briefly glance at. One was to retain the great overhanging fragments of the fallen North Arcade hanging to the north west pier of the crossing and to the west gable. This was a difficult problem, and was overcome without disturbing in any way the original face stones which were left in position, although the eccentric loading transferred to both north west pier and west gable was as much as 90 tons.

The next building I want to show you on the screen is Rievaulx Abbey. This is the earliest Cistercian House in the country, founded in 1131. Its situation is beautiful, at the head of a rich deep valley formed by a bend of the River Rye below Old Byland. The Abbey stands immediately beneath a ridge of hills, and is built on a series of terraces cut out of the foothills of the range, the church being founded on the solid ground and the monastic buildings in certain instances on made ground, while the Frater, owing to the steep fall of the ground is carried upon sub-vaults. Owing to the importance of founding the church on solid ground, it is built parallel to the range of hills upon the first cut made in the slope, and it stands, as a result, roughly north and south instead of east and west. Indeed, had the mediæval builders been so rash as to throw the church due east and west a portion would have had to be built upon filled ground or upon subvaults, which would have enormously complicated the problem.

Of the church, only the presbytery and the choir with the transepts and the east arch of the crossing remain; and the nave, when it was taken over by the Crown, presented a dimpled mound of ruins where

fallen masonry and soil was heaped up to a height of 16ft., as shown upon the screen.

The next view shows the church with the nave excavated, and the bases of the Norman piers displayed to view exactly as they were found. I shall not have time to deal with the history and character of the building, as my aim to-night is to give briefly particulars of the works undertaken to preserve the structure.

These ruins had been used as a quarry by the neighbourhood for many years, and certain difficult structural problems were involved in their preservation. As an example I show upon the screen the crushing and failure which was in evidence in the spandrel above the south west pier of the chancel. The condition of this spandrel was dangerous in the extreme, and the method adopted to preserve the stability of this arcade and the chancel was to remove the fractured stones one by one and to recore the whole of the spandrel and pier above, with strong reinforced concrete, afterwards replacing in their exact positions the stones removed for the purpose of executing the work. No single new facing stone has been used, and even in the 12 months which has transpired since the completion of the work no trace of what has been undertaken is observable.

This is only one of the problems involved in this great building, and it is hardly realised how serious the difficulties are in cutting out crushed and failing masonry under a load of over 200 tons, when the slightest error in executing the work might cause a slip involving the downfall of certainly a large portion of this great arcade.

I now propose to show you on the screen Jedburgh Abbey; one of the finest of the Border Abbeys, founded by David I. in 1118.

It is remarkable that so much remains of this Abbey, bearing in mind that it was twice burnt and three times pillaged. The earliest work is in the transepts, the lower part of the tower and the west end of the chancel. The nave is a very fine example of transitional work and you will see from the screen that the previous methods used to retain the nave in position postulate—

(1) That it was falling inward: and

(2) That it was falling outwards;

and in order to obtain the maximum advantage from both theories, great timber struts were erected between the arcades in the nave and also strong steel tension rods to resist the postulated outward movement of the arcades. As a matter of exact appraisement, however, the arcades required neither of these methods of strengthening and as if to show scorn for the methods adopted, the struts were found to be rotten at their bearing upon the walls, and the birds were nesting behind them. You will see what a vast improvement is made by removing these unessential means of preserving and strengthening the nave.

The problem of Jedburgh was one of the greatest with which the Department has had to deal. The tower was definitely failing and was in a bad state in the 15th century, as at that time the south-east and south-west piers of the tower were rebuilt by Bishop Cranston. The Norman north-east and north-west piers were left, however, and although their condition must have been serious in the 15th century, they were still further over-stressed by an addition to the upper stages of the tower in the 16th century. In the past, apprehension of the total collapse of the tower clearly existed; and the two Norman piers were encased in stone walling as shown upon the screen, while the north arch of the tower was solidly built up. Even this was not sufficient, and within quite recent times heavy modern brick buttresses and raking shores were added to the piers. Norman work gives the appearance of great solidarity and strength, but unhappily this appearance is often deceptive. This was the case at Jedburgh, where the piers were faced with rough ill-wrought ashlar only, reasonably well worked on the face, but with unsatisfactory beds joints inducing point loads on the stones. The core of these piers was made with rough rubble and weak mortar, which had no tensional strength whatsoever, and which was found to be a dry and non-cohering mass, such as would have shot out from the piers had they been opened at the base without full precautions.

It is believed that before the building was handed over to the control of the Government, a suggestion had been made to take down the tower and rebuild it, at a very heavy cost. The methods followed by the Department, however, could not contemplate this: and, first of all, an attempt was made to grout up the piers with cement. This proved a failure as an examination showed that the fine dense cement grout merely lay inert within the piers in the dusty core somewhat similarly

to the action, say, of molten lead after being poured into dry sand. When this was found, the proposal to grout was at once discarded, and a dangerous and difficult scheme was devised for the recoring of the two Norman piers. This was a very risky and precarious work as the load on each of the piers was over 600 tons and the tower had sunk 4in. with a resultant out-throw to the north of nearly 24 inches. The really terrible condition of the piers was not fully ascertained owing to their being so closely encased with modern masonry, etc., but it would be impossible to exaggerate their condition as can be shown by the following views thrown upon the screen. The scheme of srengthening proposed when the state of the tower was ascertained in 1913 was first to consolidate the upper portion very thoroughly by cement tamping and grouting, finishing with lime pointing. The great arches were centred and heavy steel needles were carried through the tower supported on clusters of four 14in. x 14in. deadshores. The process of recoring was then slowly undertaken, certain of the face stones being removed, strong jacks being inserted to support the face above, and heavy steel bars driven into the pier to prevent any fall of the core on the masons working within the piers. The process was slowly extended right up the piers and carried over the arches, and while the work was being done an accurate measuring apparatus was devised to show any movement of the tower of the minutest kind, either as to sinkage or out-throw, and after the re-coring was complete the two tower piers were carefully underpinned, and the infilling walls and buttresses removed, so that the great Norman drums are displayed with all their fractures disclosed and the great bulges remaining to view.

The actual cost of the work undertaken at Jedburgh by these methods which were slow but inexpensive, was probably one-tenth (for the whole church) of what it would have cost to take down and rebuild the tower alone. To-day the tower stands absolutely as it was with no additions thereto beyond the internal reinforced core, which is now carrying the load, with all the modern additions removed, and the amenities of this fine building are entirely preserved.

I cannot resist showing you one photograph of Carnarvon Castle, but time will not allow me to detail the works undertaken here. It is probably the finest defensive castle in this country, and, indeed, in Europe—one of the great Edwardian defensive castles dating from 1285-1322. On this building alone we could usefully spend an entire evening; but as the works of preservation here were mainly of normal character, I do not propose to describe them in detail.

I now proceed to show you on the screen examples of the method of preserving Whitby Abbey. The difference made in this building since it was taken over by the Government is very great, as it was suffering from destruction as a result of bombardment during the war, while the nave and the crossing were littered with fragments of the fallen church.

The history of the Abbey is of extraordinary interest as it was first founded upon the present site in A.D. 657, but the portion which remains is the 13th century church, consisting of nave and choir, with aisles, transepts and originally a lofty tower at the intersection, all of which were encumbered with great masses of fallen masonry from the vaulting and superstructure which fell in the nave in 1762 and the great central tower which fell in 1830.

Our recent excavations have revealed a large section of the plan of the Norman church, which will be shown in outline on the floor of the present church.

The excavations to the north of the church are now disclosing some very early buildings, which appear to have been constructed in part of "Wattle and Daub." The excavations are far from complete at the moment, but it would appear that eventually a large portion of the pre-Norman and 12th century buildings can be disclosed, the two former at least in plan.

I now show upon the screen the west front of the church, giving its condition before the bombardment by the enemy, after the bombardment and after treatment. The problem in dealing with this front was very difficult as many of the stones were shattered into fragments and the greatest difficulty was found in identifying them and replacing them in their true position. No moulded and wrought stones were put back unless they were original, and the whole of the work shown on the last slide, after the works of preservation had been completed, is such that no intelligent observer could do other than perceive accurately what is original work and what is the later work of strengthening and repair.

In Kirby Muxloe we see an example of a fortified Manor house of Tudor times, which was commenced in 1480, apparently upon the site of an earlier moated house. It is of brick construction throughout, even to the turret staircases with their complicated and enriched winding vaults and is a remarkably fine example of first-rate brickwork of the period.

Again the building was handed over in a state of utter neglect, as you will see from the screen.

The next view illustrates its character and appearance after its preservation has been accomplished by the methods which I have sought to detail to you here.

The problem of preserving a brick building is entirely different from that of a stone building, particularly where the bricks are scaling and flaking through weather and age, and through the action of growth of all kinds.

No attempt has been made, however, to re-face the scarred brickwork, but the flaking and decaying brickwork has been seized by a mastic cement and the original faces retained without any addition.

Byland Abbey, a view of which I have previously shown on the screen, was in a serious state of neglect when it was handed over to the control of the Government. It is situated on the rich fertile plain at the foot of Combe Hill, in the North Riding of Yorkshire, and there was little remaining above the ground level beyond stumps of walls heavily covered with ivy, all of which were in a state of complete disintegration and decay. There, again, the building appears to have been used as a quarry for those requiring materials for building in the district. Buttresses were robbed and the ashlar masonry removed in many instances as far as could be reached without scaffolding. It is difficult to exaggerate the appalling condition in which this building was found, and the regret we must feel over this is emphasised by the wonderful finds of enriched and carved work which we have made in excavating the church.

The magnificent detail of much of the work of this building could hardly have been apprehended before its preservation was undertaken. Moulded caps and bases, corbels and carved springers, etc., have been found which, for their simplicity and beauty of design and astonishing assurance of execution, are difficult to rival. Quite a large area of fine vitrified tile paving has been exposed in the chancel which, although somewhat rough in manufacture, has special merit for its design and planning of colour scheme.

The next building which illustrates the methods followed by the Government is Goodrich Castle, the earlier history of which is not known. It is mentioned in 1204, while the small and very perfect Keep clearly suggests that the work is among the earliest of its class in the country. The present remains, apart from the Keep, would appear to date from Norman times until the reigns of Henry V. and Henry VI.

The problem here was again grave, because of the consistent neglect of the building for well over 200 years. The stone used in the castle is a soft red sandstone, without any great strength, and this has weathered very badly and the greatest care had to be exercised in dealing with the stonework, which was fractured and split apart in many cases by the roots of ivy and young trees growing upon the wall heads.

To illustrate this highly dangerous condition, only a few weeks before the building was transferred under the Ancient Monuments Act a length of the north-west curtain wall, totalling a weight of 200 to 300 tons, fell into the moat, leaving little or no evidence of the main cause of failure, but illustrating very definitely that the masonry had little strength in resistance to shear.

We find this castle was "slighted" by an order made by Parliament in 1647, and it is probably due to this order that the castle was in such an appallingly defective condition, although it is surprising that so much remains standing, nearly 300 years after the order was made.

I propose to show on the screen, slides illustrating the character of the building before treatment and after, although the time at my disposal will not allow me to detail very particularly the works undertaken.

[Sir Frank Baines also showed upon the screen views of the following buildings and structures :—

Netley Abbey.
Hampton Court Palace.
Westminster Hall.
Richmond Castle.
Huntingtower.
Stonehenge.
Maes Howe.

Mousa Broch.

Maiden Castle, Dorchester,

explaining briefly the character of the works of preservation undertaken in each instance and illustrating how the scheme of preservation was strictly relative in every instance to the peculiar character of the work which remained.

Particularly illuminating was his description of the repair work undertaken to the great earth work of Maiden Castle, which consisted largely in repairing the huge scars of eroded chalk from the sides of the slopes and finally involved the retention of a man on this great monument of 115 acres in ext.nt, to keep down rabbits and prevent their commencing again the destruction of the great slopes of the valla, etc.]

DISCUSSION.

MR. ERNEST LAW, C.B., said that he was delighted with Sir Frank Baines's paper, the more so because he followed the line which the speaker had always advocated with regard to restoration. He had come to the meeting feeling that possibly he might find some weak point in the armour, or that he might be able to answer some criticism, but the paper had left nothing to wish for in those directions. Those who valued our old historic buildings, and who had the sentiment—not the sentimentality of ivy, against which he had inveighed for the last twenty years—of old associations, were now told, if they might believe the latest science, that these buildings had stamped upon them in their molecular formation everything that had happened within and underneath their walls. He agreed that it was impossible to fix any definite rules to be followed in restoration. Each building must be treated on its own basis, and it should always be borne in mind that buildings which were not uninhabitable ruins —buildings, that is to say, which still served some existing purpose—must be dealt with in a different way, perhaps with greater latitude in restoration, than most of the buildings which the lecturer had shown the Society that evening. If in these cases new work was put in it was better that it should harmonise with the old rather than it should flagrantly dissociate itself from the old. The questions involved here were difficult, but they deserved threshing out. In the paper the principles enunciated were those which most people who valued ancient buildings would support, and a great debt of gratitude was due to Sir Frank Baines and Mr. Peers for the wonderful work they were doing and the enthusiasm and high spirit in which that work was carried through.

MR. EDWARD P. WARREN, F.S.A., F.R.I.B.A., expressed his admiration for the work done by Sir Frank Baines. It was a great relief, after things had gone on so long without any Government recognition of the claims of ancient monuments, that they should now be in secure hands. He wished strongly to support all that the lecturer had said against ivy. He himself had been responsible for removing tons of it. On one Oxford College with which he had had to do, it acted in the most insidious manner by destroying the mortar. The secretions of acid by the ivy led to the steady disintegration of the wall, and then, by working its roots and filaments into the crevices, it shattered and destroyed the beautiful stonework. Some of the old stonework at Oxford was particularly liable to decay, and was very unsatisfactory. The task of those who had the custody of old buildings was not an enviable one. They laboured under constant anxiety lest they should destroy in attempting to preserve. In the case of buildings still in use the problem presented was different from that of buildings the use of which had passed away. His own particular responsibility had always been in connection with buildings which still had a roof, not those which had been shattered beyond habitation, and here some special consideration applied. He wished to express his personal thanks to the lecturer.

MR. A. R. POWYS (Secretary, Society for the Protection of Ancient Buildings), thanked Sir Frank Baines for his excellent paper. The country should be congratulated on having an Office of Works that put so much energy and thought into the repair of our buildings. It was only necessary to travel abroad to discover how far otherwise it might be. He noticed, from Sir Frank Baines's selections that evening, that the Office of Works up to now seemed only to have dealt with the more extensive and larger buildings. He would like to see His Majesty's Office of Works take over some examples of smaller buildings—cottages, for example, of various periods, and built in the different traditions obtaining in the different parts of the country. When buildings of this kind were kept in the same careful way as the castles and large buildings, a very great thing would have been done for the country.

MR. T. RAFFLES DAVISON feared that in spite of Sir Frank Baines's warning, a very large number of people in this country would prefer to keep the ivy, notwithstanding the ruin that it wrought. He remembered sketching many years ago one of the buildings which had been illustrated that evening, and he noticed that one of the arches had been completely spoiled in outline by the ivy. To that extent he was with Sir Frank Baines, though he must confess to some sneaking love both for the ivy and the ruin. If Sir Frank Baines could show them a way of keeping both he would be conferring a great benefit.

MR. W. A. FORSYTH said that he had greatly appreciated Sir Frank Baines's paper. Sir Frank was a master exponent of his subject, and a master craftsman in his superintendence of the work.

The country was to be congratulated on having what he considered to be an ideal Government department in the one which was concerned in the care of our old buildings. It was a department unrivalled by any similar department in other countries in the care and thoroughness with which the buildings were repaired. Sir Frank Baines had said that he did not go to the building and say to it, "This is what you want"; he waited for the building to declare what it wanted itself. That seemed to the speaker absolutely sound. The fundamental point which never varied was that no two buildings were alike, and the treatment they required was different on every occasion. The paper had been most fascinating, and if he ventured to make a criticism it was not that he was unappreciative. He admired Sir Frank Baines's vigour immensely. He had laid down the axiom that each building was to be treated as it required, but he had also told them that restoration was not to be attempted on any account whatever. Personally the speaker thought this rather a dangerous principle. There were little bits of buildings which did require some sort of restoration in order that there might be a record in stone of the original design. He thought it was risky to lay down that law. He instanced the cloisters of Westminster Abbey. The entrance to the Chapter House there was one of the most beautiful pieces of thirteenth century work ever wrought. He remembered it thirty years ago, when it was in beautiful order and full of definition, and one could see what was intended in the original carving. That had disappeared, however, in the atmosphere of London; the carving was subsequently limewashed, and now the outline was lost. That was an example which should make one hesitate before laying down the law about excluding restoration. On one point he would like a little more information. He would like to know why the grout failed at Jedburgh. Sir Frank had said that on cutting out the wall, owing to the dust in the crevice the grout had merely mingled with the dust and had not adhered to the structure. But the first operation in grouting was to remove the dust. The dust must be removed before the insertion of the grout. It should be removed either by sucking or forcing it out. He had never himself sucked it out, but he had blown it out through air holes. It was most necessary to get the dust out. Then he must comment upon Sir Frank Baines's use of ferro-concrete in these buildings. Sir Frank had said that it was almost an impossibility to resort to mediæval methods of building in the repairs. But there were many examples of mediæval repairs; they declared themselves for all time. It was not only a matter of style and design, but of material and workmanship. One could always see a repair in mediæval work as between one period and another. At Tintern Sir Frank had used ferro-concrete to a large extent. Ferro-concrete was a modern combination of cement, concrete, and, as a rule, mild steel. The speaker understood that Sir Frank had used the mild steel persistently. Mild steel was one of the most ready forms of ferrous metal for rusting. Sir Frank had put into these buildings great masses of ferro-concrete. Ferro-concrete had only been in general use for about thirty years, and Sir Frank had experimented by putting this ferro-concrete into these mediæval lime-built flexible walls. It was largely theory as to the behaviour of ferro-concrete under these circumstances and it did not do to rely on laboratory tests for the behaviour of ferro-concrete in old walls. The tops of the walls at Tintern had been stiffened with very large ferro-concrete beams. The speaker could not imagine from his experience that these ferro-concrete beams were going to lie quiescent for centuries in that wall without doing any damage. Moreover, when the time came, as it must do, to repair these ferro-concrete beams, how were they going to be reached without dismantling the walls? It was almost impossible to repair a ferro-concrete beam once it had been put into its place. Sir Frank would say that it would last five hundred years at least, but the speaker's answer would be that that was only theory. From his own experience of reinforcement generally, he thought that this method would produce failures in course of time, and much more quickly than some of them thought. It seemed to him that at Tintern Sir Frank might have developed a part of the preservation upon an ordinary stone corbel basis and let the stone corbels show. He had been rather zealous to hide his own handiwork. The speaker wished that he would show it, and not bury it in the walls.

Mr. Warren remarked on the question of reinforced concrete that some concrete reinforced with iron was in perfectly good order.

Mr. Forsyth said that, unfortunately, Mr. Warren's experience did not coincide with his own.

Sir Frank Baines, in reply, said that he quite appreciated Mr. Warren's problem—that of stone decay. That problem alone might occupy many meetings, and therefore he had left that aspect entirely alone on that occasion. He wanted, in the few moments left to him for reply, to try to convince the last speaker. One of his points concerned restoration. In the speaker's view they were not justified in restoring or adding anything to the structure that was there. He agreed that it might be desirable to have some record of beautiful decorative thirteenth century work which was fading away, but what he maintained was that such record should be produced elsewhere. The monument itself should be left as it was. Any replicas should be careful and accurate records of work constructed apart from the building which was to be preserved. With regard to Mr. Forsyth's point about grouting, he ought to have made it clear in his lecture that he was in entire agreement with the view that the essential of grouting was to exhaust the dust before starting the actual work.

But when the proportion of the dust to the whole of the internal content of the core was so high as to amount to 50 or 60 per cent. one dared not exhaust the dust. The matter then became one of trial and error. He and those who worked with him at Jedburgh did not really think it would be successful, but they exhausted a certain proportion of the dust and then started the work and put in the grout. They found that the core was so hungry and thirsty that the dust was partly absorbed and the grout lay inert like a mass of molten lead poured into dry sand. He next went on to deal with the question of reinforced concrete. He admitted all that Mr. Forsyth had to say on that subject. He honestly did not know what reinforced concrete would do in the next five hundred years. But his aim was to introduce a material which had tensional value where tensional value was required. It was, frankly, for its tensional strength that this modern material was applied in an ancient structure. He had not mentioned five hundred years in his paper, but he did believe that ferro-concrete would last for five hundred years, though, of course, he could not give any proof of this; it was simply a matter of opinion. He was not a reinforced concrete crank, but he thought there was justification for using it because they could not reproduce the statical scheme of the original structure. With regard to taking out the beams, they could, if necessary, be taken out in the same way that they were put in, although he would tremble at the job, because the taking out of really good reinforced concrete was a very difficult proposition. Mr. Forsyth had spoken as though the modern work should not be hidden. It had been said to him in connection with the roof of Westminster Hall, " You ought to have painted your steel work bright vermilion, and let it be seen by everybody." But his own strong feeling was that the problem of preservation demanded absolutely the sinking of the individuality of the technician dealing with the problem. The reality which dictated to him was the monument itself. His pride in Westminster Hall was not that he had produced a fine statical scheme as such, but because that fine statical scheme was largely, if not entirely, unobserved by a person looking at the wonderful mediæval work. It was not that they were trying to hide their light under a bushel; they were frankly seeing if they could disguise it in order that by so doing the amenities of the old work might be entirely preserved. His treatment of the subject in his paper had probably been far from clear but the subject was so huge that he was learning something fresh every day, and he really felt that now he knew less about the preservation of ancient monuments than when he started.

The Chairman (Sir Aston Webb) said that there were three things undoubtedly that did largely affect these ancient buildings—namely, stone, cement, and iron. These were all subjects for discussion, but he would like to say a word about stone. The decay of stone was one of the serious things for the whole country. Quite recently this decay had extended and had become much worse to an extraordinary degree. Sir Frank Baines had brought this matter before the Board of Research and had asked for a Committee to go into it. The speaker was made chairman of that Committee, and the Committee was meeting constantly with scientific men and architects to discover whether something could not be done to preserve the stone which was now decaying in so extraordinary a way day by day. The work was likely to be so protracted that he did not suppose he would live to see the report issued. Many of the experiments put in hand might take years to fructify, but, still, they were doing all they could with the aid of the experts who were giving their priceless knowledge and experience with a view to discovering whether there was any preservative of stone. With regard to cement, he thought it was a very useful hint never to use cement in pointing the stone. Cement seemed to have a most deleterious effect on the edge of the stone. It came out in slight efflorescence, and the edge showed decay all round. Cement certainly ought to be kept entirely away from the surface of walls, it was a most destructive thing, and its action was not yet fully known. With regard to iron, he did not speak as an expert at all, but he had always understood that iron bedded in cement lasted very well, and he had certainly seen iron so bedded which came out as bright as when it was put in. But iron bedded in lime was deleterious. Christopher Wren, who never seemed to make mistakes, did make one mistake when he used iron in the great piers of St. Paul's Cathedral, and the iron in consequence swelled and did great damage. Iron was quite a dangerous thing to use in that manner, quite as dangerous as cement. There was no knowing when it stopped, when it was still, or when it would decay. In the piers the iron rusted and seemed to divide in two parts. There was much more that could be said, but the hour was late, and he would ask them to accord a very hearty vote of thanks to Sir Frank Baines for his paper and his beautiful lantern views. His views of the buildings before they were touched by the hand of the preserver were of very great and in some cases of priceless historical interest.

The vote of thanks was accorded unanimously, and the meeting terminated.

PERSIA.

Lack of Communications.

In his recent report on the trade and industry of Persia Mr. R. H. Hadow, the Secretary in Charge of Commercial Affairs in Tehran, states that setting aside administrative and political difficulties, the principal difficulty with which trade has to cope in Persia is the lack of suitable or modern means of transport or of methods of interior com-

munication. Persia, by reason of her geographical position, the difficult nature of her mountainous country and the natural inclinations of the majority of her inhabitants, is in the position of a mediæval merchant trying to do business in a twentieth century world. The numerous parallel mountain ridges divide her trade routes into a series of separate entities; she is not yet equipped with modern roads fit for motor transport; her railways are as yet only projected, and she has no means of river communication. She has, therefore, perforce to rely on the native cart, the camel, the mule, and the donkey, except along the three roads from Duzdap to Meshed, from Tehran to Enzeli and from Kazvin to Khanikin, where roads more or less fit for light motor transport have been made of recent years. Of these routes the first and last connect with a railway at Duzdap and Khanikin respectively and so serve as important links for Persia's foreign trade, while from Enzeli on the Caspian, ships transport merchandise to and from Russia and the Caucasus. Yet even along these routes the burden of tolls for the upkeep and protection of the roads themselves weighs heavily on both mechanical and animal transport.

Trade Routes.

(1). *Bushire-Shiraz-Isafahan-Tehran.*—The road itself is not metalled and except along the portion between Bushire and Shiraz which was partly completed by the South Persia Rifles it is neither laid out nor graded, being in fact a caravan track. During the summer and autumn it is, however, used by country carts as well as pack animals, but the formidable passes between Shiraz and Bushire make it impossible for wheeled transport to use this section for commercial purposes. It has no bridges or culverts and the rivers and marshes make certain sections impassable during winter and spring. Nevertheless a large portion of Persia's foreign trade at present passes along this route. The Ministry of Public Works contemplates building this road shortly if the necessary funds are available.

(2) The *Ahwaz-Isfhhan* road through the Bakhtiari country. A caravan track used largely by pack animals and impassable for wheeled traffic.

(3) The *Duzdap-Kerman-Yezd-Isfahan route.*—A caravan track passable at certain times of the year by light motor cars. Frequented by merchandise using the Duzdap Railway which was extended during the war from Nushki via Dalbandin to connect India with Persia. Exporters of carpets from the Kerman district have during the past year used this route in preference to the mountainous road from Bander Abbas to Kerman, although the latest reports state that owing to raids by tribesmen on the road between Kerman and Duzdap the Bânder Abbas route is again coming into use.

Light motor lorries and Ford vans have been employed to some extent in this export trade but, as in the case of almost every other road in Persia, the lack of repair and petrol depots except at long distances and the rough nature of the roads necessitate carrying an undue weight of petrol and spare parts, and consequently make it unprofitable to use motor transport in Persia except for light and valuable merchandise or for transporting passengers. Cars used are mostly Ford touring cars or vans which on account of their simple and cheap construction and high ground clearance are popular in Persia. Should the projected development of proper motor roads be carried out Persia should, in the absence of railways, provide a good market for motor cars, light lorries and motor accessories. Price, rugged construction and simplicity are, however, essentials if makes not not yet known in Persia are to be popularized.

(4) The *Bander Abbas-Kerman* road.—Formerly used for the export of the greater part of the carpets and rugs made in the Kerman district and still a caravan route from the Persian Gulf for this and other merchandise to and from Central Persia. Owing to its mountainous nature it is only passable for pack animals and it is often impassable during the winter on account of snow.

(5) The *Tabriz-Hamadan* trade route, which connects Persia in normal times with the Turkish import and export route via Trebizond. A recent revival in export of piece goods through Tabriz has brought this route into use of late, but trade in North-West Persia has suffered from severe depression owing to the partial closure of the Trebizond route to Persia. The Julfa-Tabriz railway connects Persia with the Caucasan railways but is at present badly in need of repair and only occasional trains can be run when sufficient freight can be secured.

(6) *Tehran-Meshed.*—An unmetalled but carrossable road much frequented by pilgrims on their way to the Holy Shrines of Iraq or of Meshed. Also used by traffic between East Persia and the Caspian Sea ports.

A road to connect Tehran with the Caspian at Bandar-i-Baz is also at present under construction.

Cessation of Trade with Russia.

Next to the paucity of her interior communications Persia has suffered considerably from the dislocation of her pre-war import and export routes, and from the consequent necessity of redistributing her foreign trade. Before 1914 the bulk of her imports entered the country through Enzeli and the Caspian ports, or via Trebizond and Tabriz. Detailed figures for 1921-22 show that only 8.4 per cent. of Persia's foreign trade passed through the northern countries adjacent to Persia, while 91 per cent. passed through the Persian Gulf Ports, Iraq or India. The figures for the following year will, it is believed, show no appreciable difference in the proportion of trade borne by these three countries, though the total amounts will not be the same, owing to the partial revival of the Trebizond route, in spite of the difficulties attending transport through the disturbed areas of Turkey,

and to a slightly greater volume of trade by the Northern routes. In particular a service of small cargo steamers, with a capacity of approximately 800 tons of cargo each, has been started from Hamburg to Enzeli via the Russian canals and the Volga by a German firm. The first steamer reached Enzeli in November, 1922, but since that date no further steamers have reached Persian ports.

The cessation of a large proportion of the former trade with Russia has not been without effect in depressing the Persian market, and the closure of the northern trade routes has further contributed to this depression by enhancing the cost of transporting goods to North Persia which is often out of all proportion to their original cost. A few Persian merchants attended the Russian fairs at Baku and Nijni Novgorod which were revived last year, but most of the native trading community is without knowledge of conditions outside Persia, and except for the activities of the trading branches of the Soviet Government known as the Vneshtorg, Centro-Soyuz and Naftkom, no Russian agencies now cater for the export trade in such commodities as dried fruits which before the war were exported in large quantities to Russia and the Caucasus through Tabriz and the Caspian ports. Russian prints which in 1914 were universally known throughout Persia have also ceased to be imported in any quantity, and the northern markets remain relatively closed to trade, except so far as Russian petrol, kerosine oil, and similar products, are imported. Russia supplies her immediate needs by exporting rice and foodstuffs and a limited amount of timber through her commercial institutions and to some extent through Persian merchants in Gilan and Baku.

New Trade Routes.

This alteration of Persia's normal trade routes has brought into prominence at least two routes which were rarely used before the war. The first of these is the Iraq route from Basrah via Baghdad to Kermanshah. This route was always popular with Persian traders before the war and the construction of the Iraq railways from Basra to Baghdad and thence to Quaniqin near the Persian frontier has increased the facilities for importing frail or perishable goods. The virtual closure of the northern trade routes has also contributed in no small measure towards making it for the present one of Persia's chief trade routes. Imports via Kermanshah which amounted to krans 190 million in 1921-22 exceeded in volume those of any other customs post in Persia, in spite of the 1 per cent. transit tax to which all goods passing through Iraq are subjected. In winter caravans leave the metalled road near Hamadan and make their way to Teheran via Sultanabad and Qum or direct via Nobaran in order to avoid the Aveh Pass north of Hamadan and the intense cold of the Kazvin plain. Imports via Iraq include in particular a large proportion of the Manchester piece-goods which are still imported in large quantities, although the return of the kran to its norml value and the competition of other European countries whose coinage has depreciated considerably has tended to restrict these imports and to cut the profit on their sale to a fine point.

The second trade route of importance is the Indian route entering Persia at Dalbandin by the Nushki-Duzdap railway. From a position of comparative importance owing to the gulf created between it and India by the Sarhad deserts Duzdap has since the construction of this railway during the war risen to be one of Persia's principal distributing centres. The foreign trade which used this route during 1922-23 reached a total of 87 million krans, an increase of 100 per cent. over the figures for 1921-22. The railway, besides tapping the rich grain districts of Sistan and the Kainat, now feeds the districts of Kerman and Meshed, and it is probable that a large proportion of the trade which used to reach Herat, and Trans-Caspia from Russia is now supplied from India by this route. Goods exported to Persia through India by this route are entitled to a rebate of fifteen-sixteenths of the customs dues paid on foreign imports into India.

British Trade.

For the year 1921-22 the first five countries trading with Persia, in their order of importance were :—

	Imports.	Exports.	Total.
	Thousand Krans.	Thousand Krans.	Thousand Krans.
The British Empire, including India ...	462,100	159,000	621,100
Egypt	17,500	199,400	216,900
Russia	41,700	26,500	68,200
Iraq	8,300	44,400	52,700
U.S.A.	5,500	29 500	35,000

The British Empire, therefore, accounted for nearly 60 per cent. of Persia's trade, although it must be remembered that a certain quantity of the articles recorded by the customs authorities in Persia as coming from Great Britain or from India are certainly not of British manufacture or origin, but were merely consigned from these countries. This proportion has slightly decreased during the subsequent year, so far as can be ascertained, owing to a revival of trade with Italy, France and Germany in particular. The disparity between the import and export figures for the British Empire account for the depreciation of the kran on the British and Indian markets.

Persia's chief imports and exports during 1921-22 in their order of importance were :—

IMPORTS.

	Thousand Krans.
Cotton piece goods	188,600
Sugar	141,300
Nails, screws, iron piping, etc. ..	33,200
Tea	31,300

EXPORTS.

Oil and kindred substances, such as petrol, benzine, etc.	322,600
Carpets and rugs	66,100
Dried and fresh fruits	26,900
Opium	15,400

Imports during the year totalled 55 per cent. of the total foreign trade and exports 45 per cent. This ratio, so far as can be ascertained, remained virtually unchanged during the following year. Of the commodities quoted above, the British Empire during the same period supplied cotton piece goods to a value of 185 million krans and tea valued at 30 million krans, as well as almost the entire quantity of Persia's importation of nails, screws and iron piping. The chief sources of Persia's sugar were British India which supplied 67 million krans worth; Belgium, whence came 27 million krans worth; and Egypt, which supplied sugar to the value of 17 million krans. It is probable that a large proportion of the sugar supplied by India is not of Indian origin, since a certain amount is known to come from the Dutch East Indies and more is probably imported in the first place from France, Egypt and other countries for re-export to Persia via Duzdap and the Persian Gulf.

POTENTIAL WATER POWER IN NEW ZEALAND.

Estimates of the amount of available water power in New Zealand show a total of 4,076,700 horsepower, of which 759,700 horsepower is in North and 4,317,000 in South island. In the distribution of power resources, South Island is in an advantageous position, as the bulk of its potential supply is located near the deep water sounds of the west coast, where there are many sites suitable for electro-chemical and electro-metallurgical industries.

According to a report by the United States Vice-Consul at Wellington, a programme for water-power development has been prepared in which the chief sources of North Island will be utilised. These include Lake Waikaremoana, which has sufficient storage capacity to run the proposed generating plant for 21 months without rainfall, and the Waikato River project, which taps Lake Taupo. The first instalment will involve an estimated expenditure of £15,000,000 for the headworks, plant, and transmission line to Auckland and will develop 50,000 of the estimated 138,000 horsepower, which it is expected can be ultimately obtained.

State commitments up to the end of 1923 for the Lake Waikaremoana project amount to £110,000. By the end of 1924 it is proposed to spend £1,075,000, when it is expected that 24,000 horse-power will be available from this source. The method of financing hydro-electric development in New Zealand is chiefly through State aid, no projects of importance being promoted by private organisations. Southland Province, with some assistance from the State, is carrying on its development through a local body, the Southland Power Board.

Hydro-electric construction in New Zealand has been retarded by the high cost of financing, and if money were cheaper a tremendous impetus would be given to the carrying out of this project. It is recognised that the chief factor in the industrial development of Christchurch is cheap power, and among the farmers of North Island likewise a great increase in the use of small power units would result from cheaper rates and an efficient system of distribution.

REVIVAL OF SILK INDUSTRY IN VALENCIA.

An intelligent and systematic campaign to revive silk culture in Valencia has been conducted recently, writes the United States Consul at that city. The result has been the planting of some 65,000 mulberry trees on 200 farms with about 1,000 individuals actively engaged in reviving silk culture in this district. The Government encourages sericulture by offering a premium of 50 centimos (normally 5d.) per kilo of cocoons. The worms producing these cocoons before being sold, must first be examined for disease and registered by a local branch of the Department of Agriculture, the containers of the worms being stamped and sealed by the authorities.

There are at present in Valencia some 400 looms for the weaving of various silk fabrics, such as damasks and brocades. These looms are operated by hand and all are modelled on the old ones used centuries ago. They vary in width from 1 to 3 metres. Most of the operatives are men highly trained in their work. The patterns used in the manufacture of damask and brocaded silks are almost entirely copies of designs from the seventeenth and eighteenth century. So cleverly are they copied that it is frequently impossible for the layman to distinguish between the old and the new. Many are in gold or silver thread. The dyeing is done in Valencia, generally by German dyers imported for the purpose.

These brocades and damasks range in price from 25 pesetas to several hundred pesetas per metre, depending on the design, colours used, and width. They possess considerable artistic as well as economic value. Comparatively little artificial silk is used in Valencia at present and the local manufacturers are doing their best to regain their reputation for silks of the highest grades.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock :—

JANUARY 23.—G. ALBERT SMITH, "Cinematography in Natural Colours—further Developments" (with illustrations—scenes from H.R.H. The Prince of Wales's Tour in India). GEORGE E. BROWN, F.I.C., Editor of the *British Journal of Photography*, will preside.

JANUARY 30.—SIR RICHARD ARTHUR SURTEES PAGET, Bt., "The History, Development and Commercial Uses of Fused Silica." SIR HERBERT JACKSON, K.B.E., F.R.S., will preside.

FEBRUARY 6.—IYEMASA TOKUGAWA, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

FEBRUARY 13.—H. MAXWELL-LEFROY, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., will preside.

FEBRUARY 20.—PERCIVAL JAMES BURGESS, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber."

FEBRUARY 27.—CHARLES S. MYERS, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation."

MARCH 5.—MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries."

MARCH 12.—ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.)

MARCH 19.—R. L. ROBINSON, Member of the Forestry Commission, "The Forests and Timber Supply of North America." LORD LOVAT, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., will preside.

MARCH 26.—NEAL GREEN, "The Fishing Industry and its By-Products."

Dates to be hereafter announced :—

SIR LYNDEN MACASSEY, K.B.E., "London Traffic."

BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "Roads."

FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum."

J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation."

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock :—

JANUARY 18.—COLONEL H. L. CROSTHWAIT, C.I.E., R.E., retd., late Superintendent, Survey of India, "The Survey of India." Sir THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., Rector, Imperial College of Science and Technology, will preside.

FEBRUARY 15.—SIR RICHARD M. DANE, K.C.I.E., Commissioner, North India Salt Revenue, 1898-1907; Foreign Chief Inspector, Salt Revenue, China, 1913-18, "Salt Manufacture in India and China."

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons at 4.30 o'clock :—

FEBRUARY 5.—F. W. WALKER, "The Commercial Future of the Backward Races, with Special Reference to Papua." SIR GEORGE R. LE HUNTE, G.C.M.G., will preside.

MARCH 4.—THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak." THE RT. HON. LORD BEARSTED will preside.

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

CANTOR LECTURES.

ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." Three Lectures.

SYLLABUS.

LECTURE I: JANUARY 21.—Nature of Colloids. Properties of interfaces. Surface tension and adsorption. Decolourisation, gas absorption, stream line filter. The work of Hardy and Langmuir. Orientated adsorption, Catalysis, Enzmyes, Specific germicides, lubricants.

LECTURE II: JANUARY 28.—Suspension Colloids. Peptisation, protection and precipitation. Colloidal Mill. Electric cataphoresis and endosmose. Peat drying. Colloidal metals, Colloidal fuel, Ore flotation. Smokes, condensation of fumes, powdered fuels. Mists, Insecticides.

LECTURE III: FEBRUARY 4.—Emulsion Colloids. Preparation and Stabilisation. Coal tar disinfectants, Milks, Phase inversion-biological importance, greases, antigens. Soaps. Ionic micellae.

Adsorbing Gels. Silica gels, ferric oxide and alumina, clays, vaseline, rubber and textiles. Membranes, permeability. Equilibria at membranes, application to leather.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

COBB LECTURES.

Monday evenings, at 8 o'clock:—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 14..Geographical Society, 135, New Bond Street, W., 8.30 p.m. Sir Alexander Kennedy, "The Rocks and Monuments of Petra."

Architectural Association, 34, Bedford Square, W.C., 8 p.m. Paper by Prof. A. E. Richardson.

Brewing Institute of, at the Engineers' Club, Coventry Street, W., 7.30 p.m. Mr. J. Stewart, "The Season's Barleys."

Charity Organisation Society, 296, Vauxhall Bridge Road, S.W., 4.30 p.m. Dr. A. Shadwell, "The Principles of Liquor Control."

TUESDAY, JANUARY 15..Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m. Mr. N. E. Crump, "The Inter-relation and Distribution of Prices and their Incidence upon Price Stabilisation."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. W. E. Dixon, "Drug Addictions." (Lecture I.)

Transport, Institute of, at the Institute of Electrical Engineers, Savoy Place, Victoria Embankment, W.C., 5.30 p.m. Mr. A. F. Bound, "Railway Signalling and its Development."

Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Mr. Ayscough, "The Cult of the Spiritual Magistrate of the City Walls and City Moats."

Mineralogical Society, at the Geological Society, Burlington House, W., 5.30 p.m.

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Adjourned Discussion on "Superheating."

WEDNESDAY, JANUARY 16..Engineers, Junior Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m. Inaugural Meeting. Address by Sir J. Fortescue Flannery, "Marine Propulsion during Fifty Years."

United Service Institution, Whitehall, S.W., 3 p.m. Rear-Admiral Sir E. P. F. G. Grant, "The Origin of the Overseas Naval Forces, their Organisation, Training and Relation to the Imperial Services."

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. W. W. Davidson, "Stencils and their Uses."

Meteorological Society, 49, Cromwell Street, S.W., 7.30 p.m.

Transport, Institute of (N. Western Local Section), Manchester. Mr. H. Mattinson, "Passenger Transportation of Industrial Areas."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15. Prof. F. S. Boas, "Childe Harold."

THURSDAY. JANUARY 17..Pottery and Glass Trades Institution, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.45 p.m. Mr. F. A. Perry, "The Art of Table and Domestic Glassmaking."

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1. Mr. R. H. Atkinson, "A Suggested Explanation of the Allotropic Transformation of Iron." 2. Messrs. H. J. E. Dobson and I. Mason, "The Activity of Water in Aqueous Hydrochloric Acid." 3. Mr. J. R. I. Hepburn, "The Freezing of Inorganic Hydrogels."

Royal Institution, Albemarle Street, W., 5.30 p.m. Mr. W. Sickert, "Straws from Cumberland Market." (Lecture I.)

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. Mr. H. Marryat, "Electric Passenger Lifts."

Mechanical Engineers, Institution of (Local Section), Engineers' Club, Albert Square, Manchester, 7 p.m. Mr. I. H. Wright, "Recent Developments in Gears and Gear Cutting."

Economics and Political Science, London, School of. Sir Hubert L. Smith, "The Economic Laws of Art Production." (Lecture I.)

FRIDAY, JANUARY 18..Engineering Inspection, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Mr. F. Grove, "Reminiscences of Railway Work Overseas."

Medical Officers of Health, 1, Upper Montague Street, W.C. 5 p.m. Dr. M. Young, "The Public Significance of Mental Deficiency."

Royal Institution, Albemarle Street, W., 9 p.m. Prof. H. Armstrong, "The Scientific Work of Prof. Sir James Dewar."

Metals, Institute of (Local Section), University College, Singleton Park, Swansea, 7.15 p.m. Capt. L. Taverner, "The Annealing of Non-Ferrous Metals."

Geologists' Association, University College, Gower Street, W.C., 7.30 p.m. Prof. H. L. Hawkins, "The Wanderings of the Early Thames."

Engineers, Junior Institution of, 39, Victoria Street, S.W., 7.30 p.m. Mr. G. F. Tyler, "The Liability of Employers in respect of Personal Injuries to their Workmen."

SATURDAY, JANUARY 19..Royal Institution, Albemarle Street, W., 3 p.m. Mr. G. Reynolds, "Mechanical Reproduction of Music." (Lecture I.)

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FRIDAY, JANUARY 18, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 21st, at 8 p.m. (Cantor Lecture). ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." (Lecture I).

WEDNESDAY, JANUARY 23rd, at 8 p.m. (Ordinary Meeting). G. ALBERT SMITH, "Cinematography in Natural Colours—further Developments" (with illustrations—scenes from H.R.H. The Prince of Wales's Tour in India). GEORGE E. BROWN, F.I.C., Editor of the *British Journal of Photography*, will preside.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained by Fellows on application to the Secretary.

MANN JUVENILE LECTURE.

The second of the two Juvenile Lectures by Professor W. A. Bone, D.Sc., F.R.S., was delivered on Wednesday afternoon, January 9th. Mr. Alan A. Campbell Swinton, F.R.S., a Vice-President of the Society, presided.

Professor Bone referred to the researches, discoveries, and inventions of Sir Humphry Davy, George Stephenson, Michael Faraday, Smithells, Bunsen, and Welsbach. Davy's work he said, in nearly every particular, foreshadowed the whole of the progress which had been made during the last century. He taught us that to produce flame you must have an explosive mixture of gas or vapour and air, and that the mixture must be raised to a certain condition of temperature, called the ignition point. He compared Davy's definition of flame recorded in 1816 ("Flame is aeriform or gaseous matter heated to such a degree as to become luminous") with Smithells' definition made in 1916 ("The basis of flame is a glowing gas and the exciting cause, chemical action"). In making enquiries into the cause of the serious explosions in coal mines prevalent in those days, Davy discovered that methane and air only formed an explosive mixture within certain limits. This led to the invention of his miners' safety lamp, in which the flame was surrounded by gauze. The metal gauze cooled the flame in the cylinder down to below its ignition point. Examples of Davy's and Stephenson's lamps were shown, as well as a modern electric lamp, which would stand very rough usage. The devastating effect of a colliery explosion was vividly shown in a series of photographs taken in 1908, when an experimental gallery 200 feet long, composed of disused boilers, was erected on the surface. The interior of the boilers was utilised to represent as nearly as possible the actual conditions of an underground coal mine, and the force of the explosion of the fine coal dust and air was pictured on the screen.

There were a number of most interesting demonstrations showing the difference in the colour of a flame of hydrogen, carbon monoxide, and methane; the action of flame on metal gauze, as used in the safety lamp, and on a piece of asbestos paper; Smithells' separator apparatus; the structure of a candle flame and the three zones of non-combustion, partial combustion, and complete combustion; the action of the Bunsen burner and Welsbach's incandescent gas mantle which restored the luminosity taken away by the Bunsen flame; and the Meker burner. The explosive effect of the action of the Bunsen flame on a mixture of coal gas and air in a tin canister was shown. Another experiment illustrated the force of the flame when four tubes containing respectively 1, 2, 3, and 6 feet of carbon disulphide and nitric oxide were ignited, the largest tube being shattered into fragments. There was also a demonstration by means of a 14 feet tube of the different rates of speed of flame in various proportions of gas and air. Diagrammatic and other

lantern slides were projected upon the screen showing a spectrum analysis of different forms of light; the direction taken by flames; the limits of inflammability; ignition ranges of hydrogen, carbon monoxide, and methane in air and in oxygen; flame speeds; an old-fashioned steel mill used to give light in coal mines before the safety lamp was invented; the rates of explosion in a detonating coil; the measurement of flame temperature; and the lecture concluded with a demonstration of the Radiophragm, a form of incandescent surface combustion, in which an explosive mixture of gas and air is burnt at a maximum rate of intensity without the production of any flame at all.

The Chairman proposed a hearty vote of thanks to Professor Bone and congratulated him upon the extraordinary success of his experiments and on the most lucid manner in which he had explained the subject of Flame.

Professor Bone expressed his thanks to the audience, and said a very large measure of the success of the experiments was due to the enthusiasm of his two assistants, Mr. D. T. A. Townend and Mr. S. Young, and he was very glad to see how much they were appreciated.

The meeting then terminated.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

MONDAY, 17TH DECEMBER, 1923.

THE EARL OF AIRLIE, M.C., in the Chair.

THE CHAIRMAN said that he had great pleasure in introducing the reader of the paper, Mr. Noxon, Agent-General for Ontario. The province which Mr. Noxon so ably represented was perhaps, of all the provinces of Canada, one of the most suitable for British emigrants, and the first to avail itself of the facilities of the Empire Settlement Act. Mr. Noxon's whole heart was in the very important problem he would deal with that afternoon, and he (Lord Airlie) believed he was betraying no secret when he stated that Mr. Noxon was offered the appointment of Agent-General by his Government and accepted it with the special object of furthering British migration.

The paper read was :—

EMPIRE SETTLEMENT.

BY WM. C. NOXON,
Agent-General for Ontario.

It is not territory or material wealth that makes a country or an Empire great, but the quality of its people, and the principles underlying its civilisation. The greatness of the British Empire does not arise from the fact that it is an Empire upon which the sun never sets, or from the possession of its unrivalled Mercantile Marine, or from the protection of the British Navy. The greatness of the British Empire has its roots in the people of the British race, and it is the sap derived from British character which keeps green the leaves of the mighty British oak, under whose branches so many of the peoples of the earth have sheltered.

I would not be so presumptuous as to enlarge upon the past history of the British Empire to such a learned and patriotic Society as the Royal Society of Arts. You are all familiar with the lives and labours of the great Empire Builders of the past, who have handed down to us their priceless heritage.

You are familiar too, with the history of the British people. In this City of London, and this beautiful Homeland of yours, so rich in monuments of the past, it is easy to trace the birth and growth of our national consciousness, and of British institutions and British civilisation, from the days when Britain was a subject people under the yoke of the Roman Empire until to-day when we occupy, often so unassumingly, a leading place among the nations of the world. Who can measure or even imagine the pains and tribulations, the toils and fears, the strivings and setbacks, the battles and wars on sea and land, that have contributed to the steady and forward march of the British people through the centuries?

In this historic hall also, which I am so glad to know is now the property of the Royal Society of Arts, you have for many years heard from this platform and read in your *Journal* addresses and papers from men coming hot-foot to you from all corners of the British Empire, telling of the wonderful achievements of British Government and British civilisation in our own times. In looking over the list of these papers read to your Society since 1874, I have been amazed by the extent of the ground covered by these papers, and even by the extraordinary interest of their titles.

Familiar as you then are with the history of the British Empire, in the past, and with its glorious and beneficent achievements in our own times, I feel sure of a sympathetic response from you when I say

that it seems to me a tragedy that in the British Isles, in the heart of the British Empire itself, there should be an honest man, of British blood, who has no prospects of finding work, or a British boy with no chance to learn a useful occupation that will give him a livelihood, or a young woman, capable and willing, and yet receiving the dole and living in idleness.

Surely in view of the fact that there are so many people in the United Kingdom itself who are without steady employment or satisfactory prospects in life, it does not seem necessary that the Overseas Dominions should go outside the British Empire for the new settlers needed to populate their empty spaces, and continue the development of their territories and natural resources. Whether viewed from the standpoint of present expediency or future safety, it seems to me that there is no problem before the Empire to-day so urgent and important as the problem of settling the empty spaces of the British Empire with the surplus population of the Motherland ; and while it is primarily man-power that the Dominions want, I wish to emphasise again, and with all the force I can command, that man-power is not everything. It is *British* man-power the Dominions need.

It is a question how far it is safe to trust our ideals to the control of other nationalities. A close observer of affairs in the United States cannot help but be struck by the gradual submerging of their national ideals by the influence of an uninstructed foreign vote.

It has cost a very large sum both to parents and State to raise a healthy, sane, young Britisher and bring him to the point where he stands on the threshold of life. He is worthy of every consideration.

Is it Necessary or Desirable for People to Leave the United Kingdom?

Roughly speaking, the population of the United Kingdom is forty-five million, increasing at the rate of about one thousand persons a day.

In the year 1921 the excess of births over deaths in England and Wales was over one thousand a day. In 1922 it was still as high as 5,600 a week, and in the first six months of the present year it was 5,800 a week.

In England and Wales alone between 1911 and 1921, notwithstanding the enormous losses of the war, the population increased by 1,814,750. This is a much smaller increase than that of any other decennial period during the whole of the preceding century, and if the world were as settled as it was prior to the war, I have no doubt that England could take care of most of its greatly increased population.

The figures relating to the density of the population of the countries within the Empire are certainly very significant, and, if I may be permitted to say so, somewhat disquieting. In fact it is estimated that the total white population within the Empire is about sixty-five million, and as forty-five million live in the United Kingdom, it is quite evident that other parts of the Empire are not over supplied with British stock. For example :—

	Persons to the square mile.
Great Britain has	482
New Zealand has	12
The Union of South Africa has ...	3
Canada has	2
Australia has	2

There is no country within the Empire, or out of it so densely populated as England with 700 persons to the square mile.

	Persons to the square mile.
Germany has	329
The Netherlands	554
Belgium	636
Italy	337
Japan	215
Ireland	138

He would be a bold man who would say that there is nothing wrong in England having 700 people to the square mile, and Canada and Australia only two or three people to the square mile. My own view is that this glaring inequality of the distribution of the population within the Empire lies at the very root of some of the very serious social and economic troubles from which England is at present suffering. If you over-crowd a railway carriage or a house, the occupants are discontented; if a country is overcrowded to the degree where there is not enough work to go round, and where many find it impossible to make any headway at all, the general standard of life is lowered, and there is sure to be discontent and unrest.

We might divide the United Kingdom population into four classifications: 1. Those engaged in agriculture; 2. Those engaged in industrial occupations; 3. Those engaged in clerical and professional occupations; 4. The juvenile and the unemployed.

Prior to 1914 the United Kingdom was the source of supply to different parts of the Empire, and to the United States in particular, of skilled artisans. It was also the source of supply for a considerable amount of unskilled or casual labour; also agricultural workers, domestic servants and clerical and professional people. In fact, the demands of high class occupations in the different parts of the Empire and in other countries, particularly the United States, were sought for in the United Kingdom.

The ever-growing population of the British Isles has always provided an overflow of emigrants, and this fact no doubt has contributed very materially to keeping the balance between the population of the country and the requirements of its industries.

But to-day we are faced with this fact, that not only is the population of the country increasing at the rate beyond the absorbing power of its industries, but emigration is to-day operating on a very restricted scale as compared with before the war. The following table illustrates this state of things:—

MIGRANTS OF BRITISH AND IRISH NATIONALITY.

Year.	Outward.	Inward.	Balance.
1913	389,394	85,709	303,685
1921	199,477	71,367	128,110
1922	174,096	68,023	106,070

The following table shows the destination of those emigrants who have settled within the Empire:

Year.	British North America.	Australia.	New Zealand.	British South Africa.	To other Parts of Empire.	Total British Empire.
1913	190,854	56,779	14,255	10,916	12,242	285,046
1921	67,907	27,751	11,513	12,903	16,703	136,777
1922	45,818	39,099	12,259	8,772	12,462	118,410

WHAT HAS BEEN THE INCREASE IN POPULATION TO THE SELF-GOVERNING DOMINIONS BY EMIGRATION?

Of course, the figures of the numbers of people leaving this country for the Overseas Dominions do not tell the whole story. The movement of people from the Dominions must be taken into account. This information is not always very easy to discover, and as regards Canada accurate information regarding emigration—that is the number of people leaving Canada for the United States and elsewhere—has not yet been made available, and to that extent Canada's vital statistics are incomplete.

The movement of population from some parts of Eastern and Central Canada to the United States has been notorious for generations past. On the other hand the influx of United States farmers into Western Canada has also been on a very large scale.

It is rather curious to observe that the total number of immigrants entering Canada between June 1st, 1911, and June 1st 1921 (the dates of the last two censuses) was 1,812,836; the total increase of population between these dates was only 1,581,840.

This is all the more strange when one remembers that Canada enjoys a fairly large natural increase of population, namely, an excess of births over deaths.

NEW ZEALAND.

The figures relating to New Zealand show the following as representing the excess in the number of arrivals in New Zealand from the United Kingdom over departures from the Dominion to the United Kingdom:—

Year.	Net excess of arrivals over departures.
1909	8,508
1910	6,858
1911	8,624
1912	10,307
1913	12,058
1914	6,005
1915	1,468
1916	786
1917	1,430
1918	731
1919	1,109
1920	8,345
1921	approximately 9,629
1922	7,604
Total	83,462

AUSTRALIA.

The official Australian figures with regard to net immigration are very complete. These show that during the period 1861-1921—*viz.* 61 years—the gain to the Commonwealth population by excess of arrivals over departures was only 1,030,855 persons, while the gain by excess of births over deaths during the same period was 3,333,789.

The following details are also available :—

Five year periods.	Net gain by excess of arrivals over departures.
1876 to 1880	130,142
1881 to 1885	224,040
1886 to 1890	158,701
1891 to 1895	22,392
1896 to 1900	2,487
1901 to 1905	loss 16,793
1906 to 1910	57,278
1911 to 1915	99,393
1916 to 1920	71,133
1921	15,789
Net gain	764,562

The above figures—not only in the case of Australia, but also as regards Canada and New Zealand—indicate that one cannot judge the migration movement solely by the figures which give the number of emigrants who leave the United Kingdom.

They also indicate very clearly that emigration will have to be increased to a very considerable extent yet before the problem presented by the over-populated state of the United Kingdom and the under-populated conditions of the overseas Dominions is within measurable distance of being solved.

WHAT IS THE PRESENT OUTLOOK ?

There are less than three million of the population in the United Kingdom engaged in the pursuit of agriculture, and this includes auxiliary occupations such as domestic servants, gardeners, cattlemen, horsemen, gamekeepers, overseers, etc., and it is estimated that they produce from 25 to 30 per cent. of the country's food requirements.

It is also estimated that there are some fourteen millions of the population engaged in industrial work, and at least a portion of the product of their effort requires to be sent abroad to help purchase the unprovided food requirements.

HOW HAS THIS HERETOFORE BEEN ACCOMPLISHED ?

I believe it reasonable to assume that a good deal of British commercial greatness has come about from the world's confidence in British commercial justice. It might be said that England's export trade rested upon four main foundations :—

1. Cheap coal; perhaps the best coal in the world, and for home consumption one of the cheapest, and therefore one of the greatest factors in industrial activities.
2. Cheap and plentiful supply of money, not only sufficient for home requirements but sufficient for enterprise abroad, which naturally carried export trade.
3. A plentiful and cheap supply of good food. This meant reasonable wages.
4. Perhaps the most important of all—the control of the mercantile marine of the world, which to a great extent set the cost of transportation.

With these four advantages England was able to meet throughout the world the competition of other nations who possessed different advantages.

WHAT IS THE SITUATION TO-DAY ?

1. The country has still good coal, but not cheap as compared with before the war.

2. The country has still a reasonable supply of capital for home requirements, but little, if any, for outside enterprise, and capital is not as cheap as before the war.

3. The country has an ample and good supply of good food, but not cheap as compared before the war.

4. Instead of having cheap transportation the country has about the dearest water and rail transportation it has ever experienced.

Thus, nearly every favourable condition has been reversed.

NOW LET US LOOK AT THE MARKETS.

Before the war England's chief export value was in coal, and in my judgment this will continue to be the chief export value. This can hardly be called an industry.

It has a labour value, and is a diminishing asset. Every ton taken out of the mine leaves a ton less there, and each succeeding ton costs a trifle more than the preceding one.

The best markets for English industry were in the near and far East, in Europe and in the Americas, and the Empire Dominions.

WHAT IS THE CONDITION OF THESE MARKETS TO-DAY ?

During the war Japan and the United States succeeded in obtaining a fair footing

in the Near and Far East, and they are still there.

Moreover, India in particular has become a self-governing Dominion to a great extent, and has the authority to establish tariffs, which she has already done.

Thus, British commercial influence in the Near and Far East is not likely to be any greater than it was heretofore, if as great.

Take Europe, I think we shall all admit that the present generation will not see Europe sufficiently established to be the customer she was before the war.

Then take the Americas, and the self-governing Dominions. In all cases evidence goes to show that it is the desire of these countries to make more of what they need, and sell more of what they do not require. Under these circumstances one fails to see just where this country is going to establish new or increasing markets for her surplus products of industry, which is absolutely essential to her economic life. It is therefore reasonable to argue that some distribution of the ever increasing population is not only desirable but practically necessary.

WHY PEOPLE DESIRE TO EMIGRATE.

The first instinct of life is material self interest. A man says: "How am I going to live, and how am I going to live a little better or a little easier?" and thus, wherever the outlook appears to be the best from his view-point the magnet is likely to be the strongest.

The facts and figures which I have quoted in this paper prove, I think—

1. That it is desirable in the interests of the Motherland, and also in the interests of the Overseas Dominions, that a redistribution of population should be effected as far as possible.
2. That this migration from these over-populated Islands to the under-populated parts of the Empire is not at present proceeding at anything like the rate that is necessary and desirable.

Before proceeding to consider the best methods to adopt to have this condition of things righted, let us first consider very briefly the reasons and circumstances which induce people to migrate.

The first observation I would make is that the successful, the well-to-do, the contented, and those having strong-family ties, do not migrate. They are the backbone of the country. On the other hand, those who are infirm, who are aged, who are sub-normal physically, mentally, and morally, must remain in the country of their origin. Therefore, the middle line is the only one available, and this is a general average of the people. We must take into consideration that there are four distinct elements which encourage emigration:—

1.—*Ambition.* In other words, the man who finds insufficient elbow-room for his personal ambitions, or who has a marked interest in the success of his family, studies the opportunities of various countries as compared with his own before he decides where he will go. Boundaries of countries have very little deterrent effect in keeping an ambitious man from going to the place where he believes his experience and ability will earn him the best returns.

2.—*Adventure.* This is an impulse which induces migration. It is characteristic of British people. They like to see the world.

3. *Uncomfortable*, unpleasant, unhappy and unsatisfactory local economic or domestic circumstances. These themselves induce separation. Dissatisfied people are naturally inclined to emigrate.

4.—*Need.* From this source comes all dependent child migration.

The greatest obstacle to an increased flow of people from this country to the self-governing Dominions is a lack of knowledge of living conditions and opportunities in the Dominions. Within the last two weeks, and within a distance of ten miles from where we are assembled, an Englishwoman of more than ordinary intelligence asked a chemist if California belonged to England, and his reply was: "I have really forgotten what country California belongs to."

I have given you a great many statistics, because statistics have a certain interest and moreover comparative figures are necessary to show how we stand. I desire to say very emphatically, however, that the problem of Empire Emigration will never be solved by Statistics. When you are dealing with human beings, the part which Statistics are able to play is generally a small one. Human nature has a habit of ignoring figures altogether, and self-interest cannot be turned from its purpose by the most formidable array of statistics ever compiled by Government offices.

In dealing with the subject before us, one often hears it stated that there is plenty of room in the Overseas Dominions. So there is. But do not forget that there are other

things there besides vacant spaces. There are people there already, people of British blood, it is true, and proud of belonging to the British race, but nevertheless, people who have an even greater pride in the land of their adoption, whether it be Canada, Australia, New Zealand or South Africa.

The people of these young nations across the sea have their own national tradition, which is in a sense a thing apart from the common traditions of the British race. They are well versed in the history of the land of their adoption. Australia and Canada and New Zealand—and may I add even Ontario—have their own national heroes, men who are as important to them as your Nelson or Wellington, but whose names are quite unknown in England. The people who live in the Overseas Dominions know the story of their national life from its earliest beginnings, and they know the heroism, toil and perseverance of the pioneers who built their adopted country from the point when there were only a few log houses in the backwoods.

It goes without saying, therefore, that the people of the Overseas Dominions have very strong opinions regarding what is best for their own countries. They know the needs of their country better than anyone else can know them. And when it comes to a question of framing an immigration policy for the country they are living in, they naturally insist that that policy must be in keeping with their requirements.

To put it bluntly, the Dominions will not and cannot undertake to receive all the surplus population of the Motherland, irrespective of their suitability for the conditions existing in these newer lands. They are only able to absorb certain classes of people who will fit in naturally with the process of their development.

So when you hear it stated that there is no need for anyone to remain unemployed in Great Britain because the Greater Britain beyond the seas has room enough and to spare, you may take it that although such a statement may sound well, it is not practical politics.

The Kind of People the Dominions Want.

Speaking generally, the classes of workers which the Overseas Dominions can absorb, and whom they are prepared to welcome in large numbers, are as follows:—

(1.) Young women for household work;

(2.) Experienced farm labourers, both single and married;

(3.) Lads and young men who are inexperienced in farm work, but who are prepared to take employment on farms;

(4.) Farmers with capital;

(5.) People who can pay their fares, and are going out to friends already settled overseas;

(6.) People who have capital to invest in business, and later we hope skilled artisans.

Assisted Passages under the Empire Settlement Act, 1922.

Since the passing of the Empire Settlement Act, 1922, the British Government has entered into agreements with various Overseas Governments for the provision of assisted passages to help forward suitable migrants, and already many thousands of people have been successfully settled overseas. Several Governments supplement these with assisted schemes of their own.

The following is a summary of the schemes of assisted passages in operation:—

Canada.—Assisted Passages by way of loan (full passage money if required) to approved women household workers. As regards men, people in Canada who can guarantee work on the land for a friend in Great Britain or Northern Ireland, may nominate such person for an assisted passage. The nominator must advance 25 per cent. of the passage money, and the remaining 75 per cent will be advanced as a loan by the Governments of the United Kingdom and Canada. Children (boys up to 17 and girls up to 14) who are approved and whose care and settlement are undertaken by institutions such as Dr. Barnardo's Homes, the Liverpool Sheltering Homes, etc., are carried to Canada free, 50 per cent of the passage money being paid by the British Government and 50 per cent. by the Government of Canada.

Ontario.—The whole passage money is advanced as a loan where necessary to approved women household workers. Assistance up to £18 is advanced as a loan to single experienced farm workers. In the case of both men and women the Government of Ontario guarantee employment at good wages on arrival.

New Zealand.—Free passages, plus £2 bonus, are granted to approved experienced household workers and the passage money

has not to be repaid. Also passages at reduced fares to skilled single farm workers and a few married workers without families, the cost of passage being £11 per person. For persons nominated by friends in New Zealand, passages at reduced fares are available, and, where necessary, loans are granted to nominated passengers who are unable to pay the reduced fares.

Australia.—Women domestic workers are granted loans towards the cost of the passage in whole or part, if approved. Farm workers, and also manual workers who are not experienced in farm work, and who are single, and also married men who can go in advance of their families may receive a free grant of one-third, and if necessary, a loan up to the remaining two-thirds of their passage money.

All the Australian States will take boy farm learners from 15 to 18 years of age, and guarantee them situations with farmers if approved, be assisted to settle on farms of their own in Victoria and loans are granted for stock and equipment.

WHAT THE EMPIRE SETTLEMENT ACT SCHEME HAS ACCOMPLISHED.

Up to October, 1923, the number of people who have been taken from Great Britain and placed overseas under the auspices of the Empire Settlement Act, has been 37,205.

The cost to the British Government, a good deal of which may be recoverable, has been £400,000.

The number of assisted passages granted during October, 1923, in connexion with agreed schemes under the Empire Settlement Act and the total number of such passages granted from the inception of these schemes, together with the numbers of departures during the same periods, are shown in the following table :—

	Assisted passages granted in October 1923.	Total assisted passages granted.			Total. Departures.	
		1922	Jan.-Oct. 1923.	Departures in Oct. 1923.	1922.	Jan.-Oct. 1923.
Assisted Passage Schemes						
To Australia	2,123	7,058	23,659	2,591	6,118	19,952
To New Zealand	794	1,133	5,409	512	694	4,365
To Canada						
Dominion of Canada	495		3,443	478		3,344
Province of Ontario	54		1,681	67		1,309
Minor Schemes	113		1,531	113		1,468
Total	3,579	8,191	35,723	3,761	6,812	30,438

at wages ranging from 7s. 6d. to 20s. a week, with board and lodging in addition. They are regarded as apprentices for from one to three years.

Assisted passages are granted to these boys under the Empire Settlement Act.

Western Australia.—There is a group settlement scheme in this state whereby experienced and inexperienced married men may take up free land and draw sustenance allowance during the preparation of the new home. Long-term loans are granted to such settlers to facilitate the development of their properties, and housing accommodation is provided at the outset by the Government of Western Australia.

Victoria.—Single men and married men with families who can deposit with the Government a capital of at least £300 will,

The figures given in the above table include both applicants and dependents of applicants to whom assisted passages have been granted. The discrepancy between total assisted passages, 35,723, between January and October, and total departures—30,438 — during same period, is due to the fact that some people dropped out at the last moment and others have deferred their sailings until the spring.

There is no doubt in my own mind that the idea behind the Empire Settlement Act, namely, the granting of assisted passages to suitable men and women in order to enable them to go to other parts of the Empire where they will find assured employment and better prospects of life, is an excellent one.

As a matter of fact, under present condi-

tions men of the farm labouring class and domesticated young women who wish to take up household work, would have no chance at all of ever getting to Canada, Australia or New Zealand unless it were made possible for them to obtain loans covering practically the whole cost of their passage money.

I was speaking to a very experienced Shipping Agent the other day—a man who has been in business in Norfolk for many years—and he told me that practically every day he interviews about 20 or 30 men and women who come to his office anxious to find out how they can get to one of the Overseas Dominions, and in practically every case my Shipping Agent friend finds that these people are without funds.

The various schemes which the British Government have entered into with the Governments in other parts of the Empire for the purpose of granting assisted passages and undertaking the settlement of suitable people are, as far as my knowledge goes, working satisfactorily.

The wages ruling in all the Dominions for all classes of workers are generally speaking considerably higher than the wages obtainable in England.

All emigration as now carried out by the various Governments of the Overseas Dominions is thoroughly well organised. The days when people were taken to a new country and left to sink or swim when they got there are past.

There is a large demand for experienced household workers in all the Dominions, not only in the cities, but on the farms as well, and I am certain that we can continue for many years to come to settle satisfactorily many thousands of girls in such situations where they will obtain higher wages than they would be likely to obtain in England, more liberty, a fuller and freer life, and better prospects generally than was their lot in this country.

The farm homes of Ontario, as is likely in the other Dominions, where girls are wanted to assist the farmer's wife with the house work, are quite equal to the farm houses in England as regards comfort and convenience, and very much better than the generality of farm houses in Scotland and Ireland. Many of these farm houses in Ontario have electric power for all purposes.

The Soldiers' Settlement Board of Canada.

Over 27,000 ex-soldiers have been settled on farms of their own in Canada under the auspices of the Soldiers' Settlement Act of Canada, 1919. Up to the end of 1922 the Canadian Government had advanced 88 millions of dollars for this purpose. More than 25,000 of the ex-soldiers so settled were heads of families, and it is estimated that by this means 100,000 people, men, women and children have thus been added to the permanent agricultural population of Canada. In all 4,854,790 acres of Canadian land has been occupied by ex-soldiers under the scheme.

Of special interest to Great Britain is the fact that Imperial ex-service men are eligible for participation in the benefits of the Soldiers' Land Settlement Scheme of Canada. The scheme provides for the granting of loans by the Canadian Government to settlers as follows :—

1. To purchase land up to 4,500 dollars.
2. For stock and equipment up to 2,000 dollars.
3. For permanent improvements up to 1,000 dollars.

Loans are repayable in 25 consecutive annual instalments, five per cent. interest being charged.

If an applicant from Great Britain has practical farm experience in Great Britain, he is required only to be able to pay down in cash twenty per cent. of the amount involved in the purchase of the land, stock, and equipment he desires. If he is able to pay fifty per cent. of the sum required, agricultural experience is not insisted upon.

Applicants who have had at least two full years' farming experience in Canada, or one year in Canada and one year elsewhere are only required *to pay ten per cent. in cash at the time of the purchase of the land,* and no initial cash payment is required on stock and equipment.

Building up the Empire

The British Empire, as it is to-day, has been built up by migrants from the old country who have left their homes, in some cases from a desire for adventure, and in other cases under the pressure of economic necessity, and have rooted themselves in the soil of distant lands under the British flag. It goes without saying that both in the interests of the mother country and in the interests of the Overseas Dominions, it is highly desirable that migration within the empire should continue. In fact, it seems to me that under the condi-

tions in which we now move it is even more necessary than it ever was in the past.

I would be the last person in the world to try to persuade anyone in this country to migrate, even to my own native Province of Ontario, which I believe in my heart is one of the most fertile, progressive and prosperous countries in the whole world, but persuasion is not necessary in connexion with Empire migration. The migratory instinct is as strong to-day in many men and women of British blood as ever it was. There are tens of thousands of people—I might say hundreds of thousands—in this country to-day who would give almost anything for a chance of bettering themselves in some of the new countries of the Empire, but these people are unable to move unless they can be assisted. It was with the object of assisting such people who can be naturally absorbed by the Overseas Dominions that the Empire Settlement Act was placed on the Statute Book, and I can say most sincerely that in looking around I can see no better way in which public money can be expended than in the promotion of organised migration within the Empire to the fullest extent that is found practicable.

Have the people in this country stopped to think whether or not they are making of their young the finished product which the Overseas Dominions and other countries have heretofore so keenly sought after?

Does the present form of labour permit sufficient young people to be incorporated as apprentices to supply not only the future needs of this country but the future requirements of other parts of the Empire?

Is the country preparing domestic workers of a quality and in numbers to meet the demands of the other Dominions?

Is it not necessary that this country should look ahead and try and equip the young with qualifications which will insure them a livelihood in other parts of the Empire?

From a business standpoint it is estimated that the United Kingdom sells goods to the Dominions to the extent of £5 per capita, and to the outside world to the extent of five shillings per capita. At a glance, therefore, how evident it is that a better distribution of the population to the Dominions within the Empire would increase the demand for goods from this country, and thus stimulate production and lessen unemployment.

The phrase "British possessions" might also be transposed into the phrase "British Empire partners," all with a harmonious co-operation towards a common Empire interest, with the spirit of good-will and forbearance, believing that what is good for any one part of the Empire is good for the whole. A case of—

"ONE FOR ALL, AND ALL FOR ONE."

DISCUSSION.

THE CHAIRMAN (Lord Airlie) said that the Society was very much indebted to Mr. Noxon for a valuable paper. There were one or two points which he, as a member of the Oversea Settlement Committee, would like to emphasise. Mr. Noxon had pointed out the desirability of peopling the vast empty spaces of the Empire and developing our Imperial heritage by means of new settlers from this country who would bring with them the old British traditions and sympathies. He had given them significant figures as to the density of population in this country and the sparseness of the population overseas. In all that he had said on that point they were entirely at one with him and it was the realisation of this position which had led the Governments of the Empire to embark upon a policy of State-aided emigration and settlement for the benefit of the British Empire as a whole and of all its citizens. This policy had been embodied in the Empire Settlement Act under which a sum of £3,000,000 a year for 15 years was available for that purpose. The reasons for the inauguration of this new policy were obvious. The war cut across all the old currents, and in particular entirely stopped emigration to foreign countries and migration within the Empire. It was necessary to re-start this flow, and in existing conditions State aid was a necessary part of the process. They must all help to distribute the population of the Empire to the best advantage, and in doing that they must try to overcome the drift towards cities and industrialism. It was easier to do that oversea than in this country because oversea the land and other facilities for settlement were in existence in such abundance. The problem was to bring the landless man to the manless land. It was regrettable to think that there were over the whole of the British Empire fewer people engaged in agricultural pursuits than there were in France. He was glad that the author had emphasised the point that by developing the Empire we developed our best markets. It would take time to restore our European markets. In the meanwhile it was wise to pursue a policy of developing our Empire and calling upon the new world to redress the balance of the old. The critics in this country often stated that migration took away our best. On the other hand, the critics in the Dominions often said that we in the old country only gave them our worst. He thought that probably the truth lay somewhere between the two, and that the Dominions got, on

the whole, a good average Briton. This was after all as good as, if not better than, the best of any other nation in the world. He was glad, furthermore, that the author had laid stress upon the point that migration must not be regarded as the means of remedying any abnormal unemployment in this country. It did, of course, relieve unemployment, inasmuch as the men who were unemployed here obtained employment overseas, but a larger view of the problem must be taken, and they must all look forward to the time when, by the redistribution of the population of the Empire, it would be possible so to stabilise economic conditions that unemployment within the Empire would be a thing of the past. The author had spoken of the migration of boys. As a matter of fact the Oversea Settlement Committee regarded juvenile migration as one of the most promising forms of migration. Youthful migrants settled down much more readily and easily than those of mature years. It was like planting trees; a young tree more readily took root than one that was old, which perhaps never took root at all. He hoped that very shortly it would be possible to arrange with Mr. Noxon's Government a scheme for the settlement of boys from this country under particularly favourable conditions. In other parts of the Empire too the Committee was negotiating schemes for the settlement of boys both from our public and secondary schools. Last, but not least, there was the question of the migration of women. Quite apart from the fact that at the present time in this country there were considerably more women than men, they felt that everything possible ought to be done to stimulate the settlement of women in the Dominions if they were to make those British homes overseas, which were, after all, the only sure basis of permanent British settlement.

Lieut.-Colonel J. Obed Smith, Superintendent of Emigration for Canada, said that the question of migration had many sides to it and was one so full of detail that he was afraid that if Mr. Noxon or himself attempted to deal with only a few of the outstanding points they would be there all night. He appreciated the concise and forceful statement which the author had made on the general question, and he would like to add, for the comfort of those who were perhaps alarmed at the smallness of the figure quoted for State-aided emigrants, that while only 5,000 had received assistance under the Empire Settlement Act during the same period not less than 60,000 had paid their own passage. It was to no criterion of what the Act had achieved or could achieve to say that only 5,000 had gone to Canada since the 1st of April, 1922. He would like to speak of the migratory desire of the people in this little old land. He thought that he knew something about it after his own forty-two years' experience. His mind was not too old nor too young to realise that the great colonisers of this Empire, the men who left these shores sometimes not knowing whither they went and sometimes caring even less, went out desiring only one thing, and that was to carry to the uttermost parts of the earth the Union Jack and to colonise those parts with British stock. He thought of Captain Cook, in the Southern Seas, of Hudson, in the Northern Seas, and of many other great names in the wonderful history of the British people. Somehow he felt that the people nowadays had lost something of that sterling spirit which induced these men to give up the comforts of home, all the softness of existence, and go out for the sake of that greater and wider purpose, the fulfilment of which had meant so much to this island and this Empire. He had said once before, and he was rather fearful of saying it a second time, but he did say with all diffidence, that if people would realise that the Governments Overseas were really putting forward their very best efforts, aided by such organisations as the Salvation Army, the Church Army and others, and were spending enormous sums of money on both sides of the Atlantic to encourage people to go out and to place them properly on the land when they got there, the situation would acquire a new aspect. He believed it to be the fact, however, that the colonising spirit of this island had largely died away. Was it the modern conditions of labour, unemployment insurance or the "dole" which was causing it? It did seem to be the fact that the young people were not willing to go out and take their prospects in thier own hands and do their best Overseas. In saying this he was casting no reflection upon the young people in this country which he did not cast upon the young people in Canada, where he knew it was often the ambition of the man in college, for instance, simply to have a motor car. In the old land people seemed more willing to stay at home than to carry the flag Overseas. But surely in view of what was done in the war to kindle the imagination of the British people and to incite a nobler spirit among them, it was not going against human experience and endeavour to rekindle also the spirit of enterprise and adventure which in years gone by had made the Empire what it is.

Commissioner D. C. Lamb (Salvation Army) said that he had listened with great pleasure and profit to the paper, but he did not find himself in entire agreement with all that the author had said, nor indeed with what Colonel Obed Smith had said. He had been trying to look at this problem from the point of view of a would-be emigrant, and also from the statesmen's point of view—not the politicians'—and, with the Chairman's permission, he would run through a few rather disjointed observations. It was very necessary in this Empire—this great Empire on which the sun never set—to find out where the people could be put, and to put them there. From the statesmen's point of view, a very important question was that of agriculture. It might be true that men had been hanging on in this country because of the "dole," and that the agriculturists had been hanging on with the hope of a dole also. But, generally speaking, if this country were called

upon to settle whether there should be a dole or a big Navy, it would stand out for the big Navy every time. The author stated that if the world were as settled as it was prior to the war he had no doubt that England could take care of most of its greatly increased population. The speaker begged Mr. Noxon's pardon for describing that statement as nonsense. The normal overflow before the war was 350,000 people a year. Now, with the more enlightened public opinion which had arisen since the war, that figure of 350,000 would increase because people knew that there were better conditions for the bulk of them Overseas than there were at home. That was a factor which it was of no use to disguise. Then the author said that there was a demand for the settlement of these people within the Empire. But he (Commissioner Lamb) was of opinion that the English-speaking people had a destiny also which was outside the Empire, and in the case of many people, when it came to a question of bread and butter, they were not going to be confined necessarily to the Empire. In saying this he was not speaking only of Scotsmen. Then he had to pass to something which was rather unpleasant and disquieting. He referred to the population of Canada itself. He had spoken freely to his Canadian friends on that subject and he hoped that they would have a little more courage than they had had in the past, and face the question of their own vital statistics. The author had stated that in the decade 1911-21 the total increase of the Canadian population was 1,581,000, yet the increase by migration showed 1,728,000. The position was even worse than was conveyed by those figures. Those of them who knew Canada were aware that the bulk of the natural increase had been in the province of Quebec. That was notorious. Outside Quebec families were nothing like so large. What was the condition of the other provinces? It was a condition that called for statesmanlike capacity. There was a serious depopulation going on in Canada outside the province of Quebec. Then there was the question of the foreign element. He could assure them that the foreign element was all right. He had seen the foreigners in Canada going to church or engaging in business in the market places, and they were just as decent and honest as anybody else. The foreign element was all right, but these people did not speak our language. They had to be impregnated with British sentiment. He hoped that the Western provinces especially would have the attention of those responsible for Empire Settlement. He was afraid that the author was in a pessimistic vein when he said:—"Take Europe, I think we shall all admit that the present generation will not see Europe sufficiently established to be the customer she was before the war." He (Commissioner Lamb) hoped that they were going to live long enough to see a more stable condition of affairs than existed at present. After all, the world in these days moved quickly, and once people got seized of the fact that the moral issues were greater than the economic issues a vast improvement would take place. It was time that they all had more concern about moral issues, and let the economic issues adjust themselves to the moral issues. Then he had another grouse at the paper. The author had written:—"The greatest obstacle to an increased flow of people from this country to the self-governing Dominions is a lack of knowledge of living conditions and opportunities in the Dominions." That sentence would have to be revised. They were now emigrating people at the rate of 5,000 a week. He, for his own part, would guarantee to find 5,000 a day, starting from January 1st, the people being up to the standard required, if only the Dominion Governments would agree to look after them. The author further stated that when one heard it said "that there is no need for anyone to remain unemployed in Great Britain because the greater Britain beyond the seas has room enough and to spare, you may take it that although such a statement may sound well, it is not practical politics." He would like to know why. He would also like to make a reference to the scheme, mentioned by the author, of nominative passages to Canada. The nominator advanced 25 per cent. and 75 per cent. was advanced by the Governments of the United Kingdom and Canada. Wonderful Governments! But this was on the guarantee of repayment by the nominator. The Governments were taking no risks!

MR. F. C. WADE, K.C., Agent-General for British Columbia, said that he had known the author long enough to be sure that when he tackled any subject he would do so in a thorough-going way. Already in the discussion they had had the advantage of hearing two great authorities on the question of migration—Colonel Obed Smith and Commissioner Lamb. He was rather inclined to Commissioner Lamb's view on many questions. But they could not blame Colonel Smith, Mr. Noxon or anybody else because migration was not as great a success as it should be. The fact was that migration from this country was less of a success almost every year. They had talked much about the Empire Settlement Act. That Act started off with a magnificent flourish; it was to help people in this country to settle in the expanses of the country Overseas. We were spending 100 millions sterling every year on doles; how much were we prepared to spend on emigration? Three millions a year! Several years had gone by since the Empire Settlement Act was adopted. Had this country been spending even three millions a year? Had the intention of the British House of Commons been carried out? He believed that the amount spent had actually been somewhere about £400,000. Had the law, then, been defeated in its administration? An arrangement had been made lately with regard to the cattle embargo, which arrangement had been repeatedly defeated. Was the House of Commons being defeated again in this question of emigration? Had Colonel Obed Smith arrived at the proper solution when he said that we had lost that old "wanderlust" which used to characterise this great people, or was there some other reason for the default?

Then they had been told about the Soldiers' Settlement Act of Canada, under which Act great things had indeed been accomplished so far as Canadians were concerned. Under the Empire Settlement Act, the man when he got to Canada was offered a loan of $4,000 for one purpose and a loan of $2,000 for another. That was a most munificent offer, but why had it not been taken advantage of by the retired officers and other men who had served in the war? Why had "Tommy" not taken advantage of it to go to the new country? The soldier had been abroad all through the war. It could hardly be lack of adventure that kept him at home now. What was more likely to keep him at home was the provision that he had to advance 20 per cent. of the cost. That defeated the method at once. What the speaker proposed some time ago was that if the Imperial Government in London would read these two Acts together, and not separately, it would be greatly to the advantage of all concerned. He understood that the extreme provision payable to the civilian under the Empire Settlement Act was £300. Why could not they say to the ex-soldiers: "We will let you have that £300, and with that you can pay your 20 per cent. of the cost"? If that were done, very soon all the officers and men who wanted to go to the Dominions would offer themselves. But the two Acts were separate things and no attempt was made to reconcile them. Could the great propaganda of emigration from this country to the Overseas Dominions be carried on without some such provision? It was very necessary to take possession of every vantage point in Canada and guarantee that it should be prevailingly British. The problem should be looked upon as if it were a problem of war strategy. They were told continually that a great lesson was to be drawn from the fact that there had never been a fortress on the boundary line between Canada and the United States. But there was actually a fortress built by the loyalists in 1783, because it was provided that the settlement of the people should be mainly along the boundary line, so it did come about that there was a fortress of flesh and blood. There were some people who stated that it was not possible to have a system of assisted emigration. In view of the fact that every member of the Empire at present was carrying out some system of assisted migration, was it not time to get over that idea? He believed the time had come when a system of emigration, in order to be successful, should be organised as compactly, as thoroughly and as sincerely as a campaign organised in the face of the enemy. He felt that the issue facing the Empire was just as serious to-day as the one it had to face in 1914. Unless they had a system of migration which could be carried on rapidly and successfully, what guarantee was there that Australia might not be lost to the Empire by peaceful penetration? How many of those in that room knew that Washington and Oregon were originally British? They were settled by the Hudson Bay Company just like the rest of Canada. But these areas were penetrated peacefully by Americans and were eventually lost to the British flag. What was going on to-day in Canada? In order to get in behind our tariff walls, the Americans had built innumerable branch factories and they were still pursuing this policy in Canada to-day. Canada might frame its tariffs, but these were ineffective. Take British Columbia, where there existed the finest timber in the world. It belonged largely to the Americans. In that province there were about seven great pulp mills belonging largely to the Americans. British Columbia had the finest mines on the American continent outside Ontario, and these also belonged largely to the Americans. How was this condition of affairs to be met? There was only one way to meet it, and that was to fill Canada full of British subjects as quickly as possible. The points of vantage and of danger must be taken and the country made safe for the Empire. He instanced the condition of affairs in Canada in the time of Louis XIV. when it was proposed that the French settlers should be taken back to France. The French Commander wisely did not take them back to France. He rationed them on the land and settled them as farmers. That was the beginning of seigneurial tenure which laid the foundation of agriculture in the province of Quebec. In 1759 after the conquest of Quebec the Scots Greys and Frasers settled in Nova Scotia and Quebec. In 1783 the British subjects in the United States, rather than haul down the old flag, crossed the boundary into Canada and the British Government gave them land. There were 40,000 of them, and they settled 27 townships in Upper Canada and the eastern townships of Quebec, and laid the foundations of agriculture in Upper Canada. Did not this suggest the key to the solution of the emigration question? In these days, when people had not recovered from the war, the great bulk of the emigrants must be those who had not made good and who had not ready money. If the British Government could spend 50 million sterling a year they could soon place all the available emigration material from this country in the fields of Canada and Australia. It would only be done by organising as though we were in the face of another war. He would send out such emigrants in companies of 200 to, for instance, a valley in British Columbia, under a trained Canadian agriculturist. On the day on which they arrived they would commence making roads and clearing the ground. They would go on clearing their land and building their fences, and in two years—or perhaps in one year—every farm would be in working order, and within two years every farmer might have 40 acres of crop out of 100 acres. The settler would have no anxiety during this time because he would know that the Governments of the Empire were behind him. After a time he would have his farm as a going concern and instead of drifting into the cities he would be permanently attached to the soil. The expense would be practically nothing. It was true that the initial expense would be very great indeed, but every one of these men would be

required to pay back in 25 years every cent. of their loan. In the meantime the Governments that made the loan, by working shoulder to shoulder would have the security of these settled and prosperous farms. This would settle the whole question of emigration, but to potter on as we were doing now would end nowhere, it would not solve the question of unemployment, it would not assist England, and it would eventually break up the Empire. He had strong views on this subject, but he believed they were sound. He paid a tribute to the Salvation Army for what it had done in the way of assisting emigration, and congratulated it upon the extraordinarily large proportion of the men and women emigrated under its auspices who had made good. He believed that 96 per cent. of its loans made to assisted emigrants were repaid; in New Zealand the figure was 98 per cent., and the same was true of all the Australian States. By doing something on the lines he had suggested the Governments would be making one of the greatest and best investments ever made in the world.

Mr. T. R. Clougher said that he supposed he was the only person in that assembly who as a boy emigrated to Canada and settled in the backwoods of Ontario, where he spent many years. The thing which did appal prospective settlers from England was the awful loneliness of the Canadian wild, and he thought it well, as Mr. Wade had suggested, that people should go out together and settle as companies. The Government should also increase the paltry 3 millions allowed under the Empire Settlement Act to a more reasonable sum and should see that the money was spent. He drew attention to the peculiar position which Canada occupied, and which did not apply to Australia or New Zealand or any other Dominion—namely, that it was possible for men to go across the American border and find occupation which they could not get in their own country. The Americans were trying to seize the best brains in Canada, and especially had an eye upon the young men graduated from Canadian Universities and Engineering Schools. The British flag meant a great deal to those with British blood because it was associated with freedom and great traditions.

Miss E. St. John Wileman said that a deputation from the Guildhall Conference of Public and Local Authorities had recently approached the Prime Minister (Mr. Baldwin) to ask whether he would place in the general curriculum of education in this country practical instruction in agriculture and kindred out of door occupations. In reply he gave an unqualified assent. Sir Auckland Geddes, before he left for the United States, stated that, in his opinion, the great defect in the whole of the past history of emigration was that there was no testing and proving of emigrants in their native lands before embarking for other countries. In this country we were still muddling on without any practical test at all. More effective measures would have to be taken to inaugurate some efficient system of agricultural training and the testing of would-be emigrants. She and those associated with her had already formulated definite plans for dealing with, testing and preparing migrants for suitable overseas occupations.

Mr. W. L. Griffith, late Secretary, Office of the High Commissioner for Canada, proposed a vote of thanks to the author for his able and painstaking paper. So far as the Dominions were concerned it was evident that if they were to maintain their present prosperity, they must get a larger population. For his own part, he did not think it a very radical proposition to say that a British citizen should be moved free from one part of the Empire where he was an unprofitable unit to another part where he might be productive and profitable, and he agreed with Mr. Wade that the time had come when our traditional policies both in this country and in Canada must be changed. He had recently made a tour in Canada, and as a consequence of what he saw, he believed that the authorities there would have to go a great deal further than they had gone at present in looking after the men who came from Europe. At Montreal he questioned some of those who were being deported and his impression was that if they had been a little more carefully treated, although the officials did all that could be expected, if there had been more organisation to deal with the men they could have been turned into decent Canadian citizens. In Canada, until the cost of living became at least as cheap as in the United States, and the poor man in Canada wrote to the poor man in Europe saying "Come," the volume of immigration, notwithstanding the various efforts, would not be what it ought to be. During the time he had spent in the High Commissioner's Office he had seen a stream of decent citizens of middle age who had somehow failed to make good in England. He could no help feeling that the reason why they had failed to made good was because their mothers had insisted that they should wear white collars and black coats. In the changing condition of things at present he would say to the parents that instead of looking for professional and commercial openings, they should turn the minds of their sons into more useful and profitable channels. He would have no pity for any able-bodied young man who went to Canada and came back and said that he could not make a living. In the healthy atmosphere of that country he should be able to develop a physical and moral integrity which probably in the older country he would not have an opportunity of doing.

Lord Askwith, K.C.B., K.C., D.C.L., Chairman of Council, seconded the motion. The subject he said was so vast that it would be an advantage if another discussion could be held at a later date. Mr. Noxon had only been able to treat the bare fringe of the subject, but his intention was to show in a broad way what the position was.

He had briefly made an allusion to the question of free passages. Something could well be done on that line, because it was of no use asking a man who had only a few shillings to provide the pounds necessary for his passage. He believed that under a properly organised system a very large percentage of the money lent would be repaid and that the Governments would not lose by such a concession. Another question to which Mr. Noxon had only briefly alluded was that of group emigration; this matter of group and of family emigration was very important. Lord Askwith added that he wished to include in the vote of thanks not only the reader of the paper but also the Chairman, Lord Airlie, amongst whose countrymen had been some of the finest Empire-builders that Britain ever had.

The motion was carried unanimously.

MR. NOXON, in replying on behalf of Lord Airlie and himself, mentioned that in his house he had a parchment showing him to be a descendant of the New England loyalists. He was glad that the discussion had been so full; but it would take a whole day to exhaust any one division of the subject.

The meeting then ended.

LA VIE INDUSTRIELLE EN FRANCE.

LE LABORATOIRE "AMPÈRE" POUR LES ESSAIS A 1 MILLION DE VOLTS.

Le 11 décembre a été inauguré à Ivry (banlieue de Paris) le laboratoire installé par la Compagnie Générale d'Electro-Céramique, pour des essais à très haute tension. Ce laboratoire auquel on a donné le nom du grand physicien AMPÈRE, est équipé pour produire couramment des tensions supérieures à 1,000,000 de volts. L'inauguration, par le sous-Secrétaire d'Etat de l'Enseignement technique et le professeur D'Arsonval, président de la Compagnie, a été accompagnée d'une série d'expériences intéressantes. C'est la première fois que la tension de 1 million de volts a été produite en Europe.

Le bâtiment édifié spécialement pour le laboratoire, a 36 mètres de longueur, 20 mètres de largeur et 18 mètres de hauteur. Il est donc suffisamment vaste pour que l'influence des parois soit négligeable.

Le courant est produit par un alternateur étudié spécialement et muni d'amortisseurs, grâce auxquels la courbe de tension ne diffère pas de la sinuosité théorique de plus de 2%, quel que soit le débit.

Les six extrémités des enroulements du stator sont sorties, ce qui permet, soit de n'employer qu'une phase, soit, si l'installation fonctionne en triphasé, de faire des connexions en étoile ou en triangle. L'alternateur est entraîné par un moteur asynchrone synchronisé, qui démarre en asynchrone sous tension réduite, le rotor étant court-circuité lui-même; lorsque la vitesse de régime est atteinte, on y envoie du courant continu, et le moteur est "accroché." De cette façon, on a un courant de fréquence constante à l'alternateur. La puissance est de près de 200 chevaux.

Le laboratoire contient 3 auto-transformateurs monophasés 500/375.000 volts, munis d'enroulements de compensation réduisant la dispersion dans une forte proportion.

En excitant les trois transformateurs au moyen des 3 phases de l'alternateur, on obtient aux sorties secondaires du courant triphasé à 650.000 volts entre phases.

En branchant, au contraire, le primaire du premier transformateur sur une phase de l'alternateur dont le neutre est à la terre, et en excitant respectivement les 2ème et 3ème transformateurs au moyen de quelques spires de l'enroulement des 1er et 2ème, on peut obtenir entre la sortie du secondaire du 3ème transformateur et la terre des tensions supérieures à 1 million de volts efficaces, soit plus de 1.400.000 volts de crête.

Les principales expériences effectuées le jour de l'inauguration ont été les suivantes:

La réalisation d'un champ tournant à 300.000 volts; la production d'étincelles à 500 000 volts et à 1 million de volts entre des sphères de 1 mètre de diamètre ou entre des pointes; la charge statique d'une personne isolée du sol sous l'action d'un champ à haute tension; enfin l'essai de contournement par l'arc d'une chaîne d'isolateurs à 1 million de volts.

C'est principalement pour les essais d'isolateurs que ce laboratoire a été établi; il doit concourir à la production du matériel d'électrification à haute tension prévu en France. Il servira également à des recherches scientifiques et industrielles générales sur les très hautes tensions.

EXPOSITION DE PHYSIQUE ET DE TELEGRAPHIE SANS FIL.

(Paris, 30 Novembre-24 Décembre.)

La Société française de Physique, à l'occasion de son cinquantenaire, a pris l'initiative d'organiser, au Grand Palais des Champs-Elysées, une importante exposition de Physique et de T.S.F., qui constitue une innovation dont le succès s'est affirmé très grand, à tel point qu'on a dû prolonger d'une semaine sa durée.

Dans le cadre, vaste et élégamment décoré, de la nef vitrée du Palais, le visiteur rencontrait d'abord quelques appareils anciens, fort curieux, tels qu'une machine pneumatique de NOLLET, du 18e siècle, une lentille à échelons de FRESNEL, des spécimens de transmissions de dessins et photographies par le système CASELLI, vers 1860, et par le système BELIN, en 1907. Ce dernier système a été fortement perfectionné depuis lors.

A quelques pas de ces instruments anciens, les appareils les plus modernes s'offraient à la curiosité du visiteur: un poste de sectionnement électrique en plein air à 150,000 volts, avec disjoncteurs tripolaires, par exemple. Nous ne pouvons que citer ici quelques stands, et d'abord l'exposition rétrospective de la Société du Gaz de Paris, montrant

tous les genres de becs employés depuis 1830 jusqu'à aujourd'hui pour éclairer les rues de la capitale; puis, la "salle d'optique," série de stands où l'on exécutait des expériences et démonstrations nécessitant l'obscurité.

Parmi les expositions des collectivités, mentionnons celle du Conservatiore des Arts de Métiers, offrant en particulier une copie du mètre prototype; celle du Radio-Club; celle de l'Office national des Inventions; celle de la Société Française de Physique.

N'oublions pas, enfin, de signaler quelques expositions des grands constructeurs français, tels que la Cie Thomsom-Houston, le Matériel téléphonique, la Société Alsacienne de Constructions Mécaniques, la Soudure autogène, le Comité électrométallurgique de France, les Aciéries d'Imphy (Nièvre), la Cie de Fives-Lille, la Cie générale d'Electricité, la Cie Générale d'Electro-Céramique, les Ateliers de Constructions électriques de Delle, etc., qui avaient mis en vue leurs plus intéressantes fabrications.

L'électricité, et particulièrement ses emplois pour l'éclairage et pour la radiographie, tenaient naturellement la place principale dans l'Exposition; en particulier, les constructeurs de postes de radio pour amateurs de broadcasting avaient apporté, en grand nombre, leurs dispositifs les plus récents, permettant d'entendre les émissions françaises et anglaises.

Un Nouveau Procédé de Décintrement des Ponts en Béton Armé.

Les ponts en maçonnerie ou en béton armé sont généralement construits sur une charpente en bois reposant à sa base sur des "boîtes à sable." Pour décintrer le pont, on ouvre dans chaque boîte un orifice qui permet l'écoulement du sable, et par suite, la descente de tout le cintre.

Cette méthode classique laisse la voûte prendre sa flèche naturellement, sans possibilité de la corriger. Un nouveau procédé de décintrement très hardi vient d'être imaginé par M. Freyssinet, qui l'a employé à plusieurs grands ouvrages en béton armé. Dans le procédé Freyssinet, l'arc en béton armé n'est pas claveté avant le décintrement: on laisse au sommet un espace vide jusqu'à la fin de la construction. Pour décintrer, on dispose dans cet espace, horizontalement, des vérins hydrauliques très puisants. On les met en action, et les deux moitiés de l'arc se soulèvent, grâce à leur élasticité, déchargeant le cintre et l'échafaudage. On remplit alors de béton riche l'intervalle des arcs, de part et d'autre des vérins, et l'on peut retirer ceux-ci.

Le grand avantage de ce système est que le constructeur est maître, jusqu'au dernier moment, de la flèche du pont. Il peut, en agissant sur les vérins, modifier la forme de la voûte pour faire coïncider exactement la fibre moyenne avec la courbe théorique prévue par le calcul. Il peut donc corriger au besoin un affaissement excessif des arcs. De plus, on connaît exactement l'effort à la clé de l'ouvrage, puisque c'est la force exercée par les vérins pour maintenir les arcs ouverts Enfin, s'il se produit une fissure ou un accident quelconque à la maçonnerie pendant l'opération du décintrement, on peut ramener la construction sur son cintre presque instantanément, puisqu'elle ne s'est soulevée que de quelques centimètres, et que le cintre n'a pas bougé.

Ce procédé a été appliqué avec succès, d'abord au pont de Villeneuve-sur-Lot, puis à celui de St. Pierre-du-Vauvray, sur la Seine, près de Rouen, dont l'ouverture de 134 mètres est la plus grande portée atteinte jusqu'ici par un arc en béton armé.

NOTES ON BOOKS.

The New Industrial Era. By Sir Charles W. Macara, Bt. Manchester: Sherratt and Hughes.

The contents of this volume consist for the most part of articles contributed by the author to the press in 1922 and 1923. While the title is general the chapters deal almost entirely with various problems and aspects of the cotton trade. There can be very few people who have had a longer or more intimate connexion with cotton than Sir Charles Macara, and in his services to the industry—notable amongst them his triumph in the matter of the Brooklands Agreement—he has been second to none. Whatever he has to say of this trade, therefore, is of the greatest authority and weight.

It is extremely refreshing to note that, in spite of the present depression, Sir Charles has a fine faith in the ultimate prosperity of our cotton trade. We hear much of rivalry from other countries. What does Sir Charles say about America, for instance? "While we have the inherited skill of generations to produce our cotton goods, the Americans have to carry on the cotton industry as best they can with an alien population. If you go into an American cotton mill you will find workpeople of five or six different nationalities engaged, and the personnel is always changing. The employers never know whom they will get next—Italians or Spaniards or Poles or what not; and the running of a mill under such conditions is like a Tower of Babel.

"Very few of our cotton operatives go from here to work in America, and when they go they soon want to come back. They know how inferior the conditions are in American cotton mill towns."

As to the cry of "cheap yellow labour" Sir Charles is no less optimistic. He learnt from a Japanese gentleman, sent over by the Japanese Government, that nearly all the operatives in Japanese cotton mills come fresh from the fields, and require all kinds of inducements to get them to remain at factory work. According to him, there is little in the cry of Japanese competition. "To begin with, the Japanese are dependent on English machinery, which costs them double what it costs the English manufacturer to erect. Then the employers have to build houses for their workers, provide them with amusements, and educate their children. They are by no means in a strong position, and the weakest thing of all about their position is

that as soon as their workpeople have saved a little money they are off again to the country, and the employers have to start with a fresh set of workers whom they have to train."

The whole book is full of ripe wisdom and information, and will appeal not only to students of the cotton trade but to all interested in economics and the relations between employers and employed.

PLAN COPYING IN BLACK LINES FOR HOT COUNTRIES. By B. J. Hall, M.I.Mech.E., London: Sir Isaac Pitman & Sons, Ltd. 2*s.* 6*d.* net.

Engineers and architects working in hot climates are familiar with the difficulty of securing good black line copies of their drawings. The process described in this booklet is based on one which was largely used by photographic printers in this country before the introduction of "Ordoverax," although modifications have been made to suit special conditions. The author states that no great technical skill is involved in using the process: with a little practice the native operators having some experience in blue printing will be able to produce satisfactory copies. The process, which is fairly simple, is very clearly described, and seems likely to prove of great service to those for whom it is intended.

GROWTH OF CHINESE LACE INDUSTRY

China's lace trade, although still essentially a home industry, is becoming an important factor in the nation's commerce. Exports of Chinese lace have mounted from the negligible figure of 140,682 haikwan taels in 1914 to 5,230,284 haikwan taels in 1921, which latter value represents an increase of 95 per cent. over the 1920 exports of 2,678,530 taels. The United States' share of this trade was 4,195,494 taels in 1921. Australia ranks second, Great Britain third, and Canada fourth as buyers of Chinese lace.

Chefoo formerly led in exports of lace from China, but in 1919 Shanghai rose to first place with about three-quarters of the total shipments to its credit. Chefoo still holds second place, and small amounts are being shipped from Ningpo, Swatow and Nanking.

According to a report by the United States Assistant Trade Commissioner at Shanghai. silk torchon and Cluny laces were originally introduced into Chefoo (Shantung Province) by missionaries, who took this means of teaching the native women and girls a profitable home employment. In 1895 the industry was placed on a commercial basis by the establishment of the Chefoo Industrial Mission for the sale of these products. Chefoo's entrance into competition with European laces came during 1910, when thread laces were manufactured by using Belgian and French patterns. Up to this time Australia had taken the bulk of the torchon laces, while the silk Clunys found their way to America.

Sales of lace to the United States did not assume commercial importance, however, until the introduction of filet-lace making into China. During 1916 two American firms began buying filet laces, which at that time could only be obtained in small amounts by combing the interior towns and cities. Although the industry was started in Chefoo, the real centres to-day are Pootung (Shanghai's industrial district) and the Wusih (about 70 miles north of Shanghai). The better grades of filet lace are made in the Wusih district, where the workers have had the advantage of the industrial school training. The narrow widths (six and nine holes) are produced here. Pootung claims to have about 230 establishments, employing approximately 25,000 women workers. In this district, which manufactures the bulk of the wider filet (from 30 to 50 holes), the patterns are worked in by needle in what is known as running stitch, and are somewhat inferior to the Wusih product. The combined output of Pootung and Wusih is estimated at over £300,000 annually. Most of the filet laces are produced by women and children, although there are some men workers, chiefly on the larger pieces, such as table covers and bedspreads.

During 1920 the Irish lace industry was introduced into Swatow and adjoining districts, and it is claimed that they are turning out a higher class article than is produced in Ireland. One American firm has 18,000 workers employed in this district with an annual output of over £250,000. A small amount of Venetian or mosaic laces is made in the Shanghai district.

The net or mesh which is used as the basis of filet lace is made entirely by hand, principally in the Ningpo district of Chekiang Province. It is collected by agents who bring it to the lace centres of Pootung and Wusih.

British thread has always held a dominant position in the industry, although during the war Japanese thread entered into competition with it. The Japanese thread is said to be defective in wearing qualities, the strands separating when the laces are washed, thereby rendering them loose and uneven. Recently a Chinese-made thread has entered the market which is a trifle better in quality than the Japanese. So far a very small amount has been available, but it is making itself felt in the trade. American threads have been imported in negligible quantities. A limited amount of French and Belgium thread is imported for the finest grades of laces.

The thread is furnished to the workers by native brokers, dealers, or buyers, who pay their wage upon delivery of the finished products. The Shanghai scale of wages ranges from eight to fifteen cents per day, the average wage being 10 cents silver.

Filet and other laces are usually bought up by scouts or native brokers touring the various lace districts. They are then brought into the markets, such as Shanghai, and sold to exporting concerns in whose warehouses they are inspected for the following defects: (1) Torn borders, (2) rust, (3) broken holes, (4) soiled condition. Laces

are usually graded into three classes, rejects being disposed of in job lots to Chinese peddlers.

Great difficulty is experienced in getting the Chinese lace workers to realise the importance of cleanliness. Often as high as one-third of a shipment must be classed as seconds owing to soiled condition. Rigid foreign supervision alone reduces this fault to a minimum, but where the laces are collected from Chinese homes it has been found impossible to inculcate the desirability of cleanliness.

After inspection the laces are measured, carded and labelled preparatory to shipment, bolts running from 12 to 100 yards each. The lace is then packed in cardboard boxes holding 50 pounds of lace, usually 50 bolts. These boxes are then wrapped in oiled paper, covered with muslin, sewed, and stencilled for shipment, which is usually by parcel post.

AMERICAN versus EUROPEAN SUMAC.

The Research Division of the United States Bureau of Foreign and Domestic Commerce has prepared a memorandum on the importance of sumac to the American tanner from which the following is taken:—

The sumac of commerce consists of the dried leaves, leaf stems, and stalks from various plants of the Rhus family, which are found abundantly in almost all regions of the temperate zones. These varieties however, do not all possess the the same value as tanning agents. The principal European species and most valued for their tannin content, are the Silician sumac (*Rhus corairia*) and that from central Italy (*Rhus continus*), which varieties are also found in Yugoslavia; the sumac of France, Spain, and Greece belongs in the same category. American sumac is obtained from various species of Rhus, the best thing being that known as white sumac derived from *Rhus glabra;* dwarf sumac, from *Rhus copallina:* and staghorn sumac, from *Rhus hirta.* There are several other varieties, but their yield of tannic acid is insufficent to render them commercially valuable.

Sumac is found abundantly in the United States and is especially accessible east of the Mississippi River, from Maine to Georgia. Sumac is harvested on a large scale in Virginia, North Carolina, Maryland, and Pennsylvania. The American plant, owing to careless gathering and curing, gives a darker coloured leather than the sumac imported from Sicily, and, since sumac is mainly used for tanning light-coloured leather, this characteristic renders the American product less desirable than the Silician and therefore decreases its value.

Buyers of sumac leaves for grinding depend largely upon colour for determination of value. A bright green colour is evidence that the leaves have suffered neither from rain after being gathered nor from heating during the process of drying. Sumac should be kept in the drying house for at least one month before being sent to market. The leaves of the upper extremities of the stalks are always richer in tannic acid than those of the base; and the increase in the age of the plant is accompanied by a general diminution in this acid. To insure a maximum value for tanning purposes the leaves should be gathered when full of sap, before they have begun to wither or have been affected by frost. For the purpose of tanning white and light coloured leathers, collection should be made in June; but when darker colours are desired, collection should be made in July. The percentage of tanning in American sumac gathered in June is 23, while that gathered in July is 27. It is evident therefore that if a maximum of tannic acid is desired the sumac should be collected in July; but if delicacy of tint is the main object, then collections should be made in June. The colouring matter in the leaves has an important influence in determining the value of the product. The portions of the plant usually considered of value for tanning purposes are the leaves and the stems; but as the stalks contain from 5 to 10 per cent. tannin—an amount too large to discard, considering expense incurred in collecting and hauling to market—an extract could be made from them and the off-coloured leaves that would be a satisfactory tannage where colour is not of premium importance.

The tannin content of good sumac ranges from 25 to 28 per cent.; although some samples have, on analysis, been found to contain from 32 to 35 per cent. of a tannin allied to gallotannic, with some ellagitannic acid, and a colouring matter which gives yellows with alumina and tin mordants. Similar analyses have proved that the tannin content of dwarf sumac ranges from 19 to 35 per cent. that of the staghorn, from 21 to 30 per cent.; and that of white sumac from 21 to 28 per cent.

For white or light-coloured leathers, sumac is the best tannage known; hence its general use in the tanning of moroccos, roans, skivers, glove leathers, etc. It is also used for brightening leathers of darker tannages, such as mimosa and gambia, the colouring matters of which warm sumac liquors readily dissolve. Sumac-tanned leathers are less liable to decay than those of other tannages and are largely used for book-binding, and other purposes in which durability is a primary requisite.

Extracts occur as liquids of 42° and 51°, containing about 22 and 26 per cent. of tannin respectively. The domestic production in the United States of sumac extract from both native and foreign leaf in 1914 amounted to 4,512,361 pounds, valued at $129,631; and in 1919 (the latest year for which statistics are available), to 4,507,433 pounds, valued at $253,088. The domestic consumption, however of the prepared extract in 1919 aggregated 6,669,642 pounds together with 4,656,000 pounds of raw sumac representing a total of 11,325,642 pounds, valued at a $590,381. One pound of sumac extract contains approximately the same amount of tannin as one pound of sumac leaf.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock :—

JANUARY 23.—G. ALBERT SMITH, "Cinematography in Natural Colours—further Developments" (with illustrations—scenes from H.R.H. The Prince of Wales's Tour in India). GEORGE E. BROWN, F.I.C., Editor of the *British Journal of Photography*, will preside.

JANUARY 30.—SIR RICHARD ARTHUR SURTEES PAGET, Bt., "The History, Development and Commercial Uses of Fused Silica." SIR HERBERT JACKSON, K.B.E., F.R.S., will preside.

FEBRUARY 6.—IYEMASA TOKUGAWA, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

FEBRUARY 13.—H. MAXWELL-LEFROY, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., will preside.

FEBRUARY 20.—PERCIVAL JAMES BURGESS, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber."

FEBRUARY 27.—CHARLES S. MYERS, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation."

MARCH 5.—MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries."

MARCH 12.—ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.)

MARCH 19.—R. L. ROBINSON, Member of the Forestry Commission, "The Forests and Timber Supply of North America." LORD LOVAT, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., will preside.

MARCH 26.—NEAL GREEN, "The Fishing Industry and its By-Products."

Dates to be hereafter announced :—

SIR LYNDEN MACASSEY, K.B.E., "London Traffic."

BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "Roads."

FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum."

J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation."

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock :—

FEBRUARY 15.—SIR RICHARD M. DANE, K.C.I.E., Commissioner, North India Salt Revenue, 1898-1907; Foreign Chief Inspector, Salt Revenue, China, 1913-18, "Salt Manufacture in India and China."

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons at 4.30 o'clock :—

FEBRUARY 5.—F. W. WALKER, "The Commercial Future of the Backward Races, with Special Reference to Papua." SIR GEORGE R. LE HUNTE, G.C.M.G., will preside.

MARCH 4.—THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak." THE RT. HON. LORD BEARSTED will preside.

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

CANTOR LECTURES.

ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." Three Lectures.

SYLLABUS.

LECTURE I: JANUARY 21.—Nature of Colloids. Properties of interfaces. Surface tension and adsorption. Decolourisation, gas absorption, stream line filter. The work of Hardy and Langmuir. Orientated adsorption, Catalysis, Enzymes, Specific germicides, lubricants.

LECTURE II: JANUARY 28.—Suspension Colloids. Peptisation, protection and precipitation. Colloidal Mill. Electric cataphoresis and endosmose. Peat drying. Colloidal metals, Colloidal fuel, Ore flotation Smokes, condensation of fumes, powdered fuels. Mists, Insecticides.

LECTURE III: FEBRUARY 4.—Emulsion Colloids. Preparation and Stabilisation. Coal tar disinfectants, Milks, Phase inversion-biological importance, greases, antigens. Soaps. Ionic micellae.

Adsorbing Gels. Silica gels, ferric oxide and alumina, clays, vaseline, rubber and textiles. Membranes, permeability. Equilibria at membranes, application to leather.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

COBB LECTURES.

Monday evenings, at 8 o'clock:—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 21..British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Prof. P. Nobbs, "Architecture in Canada."
Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Mr. E. J. Sewell, "The Historical Value of the Book of Jonah" (being the Gunning Prize Essay for 1923).
Geographical Society, Lowther Lodge, Kensington Gore, S.W., 5 p.m. Captain P. K. Boulnois, "Field Longitudes by Wireless."
Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Informal Meeting). Mr. E. H. Shaughnessy, "Broadcasting."
Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Graduates' Section.) Mr. E. L. Diamond, "Recent Improvements in Locomotive Efficiency."
University of London, King's College, Strand, W.C., 6 p.m. M. E. Augier, "Le Théatre Francais en 1850" (in French.)
5.30 p.m. Dr. O. Voladio, "Channels of Modern Czech Literature." (Lecture I.)

TUESDAY, JANUARY 22..Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Mr J S. Dow, "Co-ordination of Research in Illuminating Engineering and Some Practical Applications."
Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.
Photographic Society, 35, Russell Square, W.C., 7 p.m. (Meeting of the Kinematograph Group). Messrs. D. Bloch, L. Everleigh and others on "Cinematograph Negative Film: What We Want and What We Get."
Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. W. E. Dixon, "Drug Addictions." (Lecture II.)
Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Commander W. F. Boothby, "Empire Air Service to India and Australia."
University of London, King's College, Strand, W.C., 5.30 p.m. Rev. P. Dearmer, "Seventeenth Century Art—Part II. Northern Europe." (Lecture I.)
5.30 p.m. Sir Bernard Pares, "Russia before Peter the Great to 1861." (Lecture I.)
5.30 p.m. Mr. J. R. Beard, "Electric Power Mains." (Lecture I.)

WEDNESDAY, JANUARY 23..Microscopical Society, 20, Hanover Square, W., 7 p.m. (1) Captain J. W. Bamfylde, "Some Failures in Steel as revealed by the Miscroscope and recorded by Photography." (2) Mr. H. B. Milner, "The Use of the Miscroscope in the Petroleum Industry."
University of London, University College, Gower Street, W.C., 3 p.m. Prof. E. G. Gardner, "Problems of the Inferno" (Lecture I.)
At King's College, Strand, W.C., 5.30 p.m. Mr. C. R. Peers, "The Place of Art in the Study of Mediæval History."
At Kingsway Hall, Kingsway, W.C., 6.30 p.m., Mr. L. V. Wilkinson, "Representative Living English Writers." (Lecture I.)
Constructive Birth Control, Society for, Essex Hall, Strand, 8 p.m. Rev. D. Cameron, "The Race Problem in Scotland."

THURSDAY, JANUARY 24..Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Dr. J. E. Ramsbottom, "Dopes and Fabrics."
Royal Society, Burlington House, Piccadilly, W, 4.30 p.m.
Linnean Society, Burlington House, Piccadilly, W., 5 p.m.
Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.
Auctioneers, and Estate Agents, Institute, 34, Russell Square, W.C., 7.30 p.m. (Junior Section.) Mr. H. Knapton, "Second-hand Books in Relation to the Auctioneer in General Practice."
Economics and Political Science, London School of, Houghton Street, Aldwych, W.C., 5 p.m. Sir Hubert L. Smith, "The Economic Laws of Art Production." (Lecture II.)
Royal Institution, Albemarle Street, W., 5.15 p.m. Mr. W. Sickert, "Straws from Cumberland Market." (Lecture II.)
Mechanical Engineers, Institution of, (Midland Section), The University, Edmund Street, Birmingham, 7.30 p.m. Mr. C. Jones, "Mechanical and Electrical Equipment as Applied to Coal Mining."
University of London, University College, Gower Street, W.C, 5.15 p.m. Prof. J. E. G. de Montmorency, "Comparative Customary Law of Europe and Asia." (Lecture I.).
8 p.m. Prof. H. E. Butler, "Roman Private Life." (Lecture I.)
At (R.F.H.) School of Medicine for Women, Hunter Street, W.C., 5 p.m. Prof. W. C. Cullis, "Respiratory Exchanges." (Lecture I.)

FRIDAY, JANUARY 25. Royal Institution, Albemarle Street, W., 9 p.m. Sir Aston Webb, "The Future Development of London"
Mechanical Engineers, Institution of, Storey's Gate, S.W., 6 p.m. Major G. Le Q Martel, "The Progress of Mechanical Engineering in the Military Service."
Aeronautical Engineers, Institution of, at the Engineers Club, Coventry Street, W., 6.30 p.m. Lt.-Col. V. C. Richmond, "Some Problems in Connection with the Structure of Rigid Air Ships."
Physical Society, Imperial College of Science and Technology, South Kensington, S.W., 5 p.m.
Engineers, Junior Institute of, 39, Victoria Street, S.W., 7.30 p.m. Prof. E Edser, "Molecular Attraction and its Relation to Engineering."
Shakespeare Association, King's College, Strand, W.C., 5.30 p.m. Dr. W. Starkie "Shakespeare and the Spanish Drama."

SATURDAY, JANUARY 26..Royal Institution, Albemarle Street, W., 3 p.m. Mr. W. Wallace, "The Couperin Dynasty."

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FRIDAY, JANUARY 25, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 28th, at 8 p.m. (Cantor Lecture). ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." (Lecture II.)

WEDNESDAY, JANUARY 30th, at 8 p.m. (Ordinary Meeting.) SIR RICHARD ARTHUR SURTEES PAGET, Bt., "The History, Development and Commercial Uses of Fused Silica." SIR HERBERT JACKSON, K.B.E., F.R.S., will preside.

INDIAN SECTION.

FRIDAY, JANUARY 18th, 1924; SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., Rector, Imperial College of Science and Technology, in the Chair.

A paper on "The Survey of India" was read by COLONEL H. L. CROSTHWAIT, C.I.E., R.E., retd., late Superintendent, Survey of India.

The paper and discussion will be published in a subsequent number of the *Journal.*

CANTOR LECTURE.

On MONDAY, JANUARY 21st, 1924, DR. ERIC K. RIDEAL, M.B.E., B.A., D.Sc., F.I.C., of the Chemical Laboratory, The University, Cambridge, delivered the first lecture of his course on "Colloid Chemistry."

The lectures will be published in the *Journal* during the summer recess.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Precise Length Measurements," by Mr. J. E. Sears, Jun., C.B.E., M.A., M.I.Mech.E., A.M.Inst.C.E., have been reprinted from the *Journal*, and the pamphlet (price 4*s.*) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures, which have been reprinted and are still on sale, can also be obtained on application.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained by Fellows on application to the Secretary.

MANN JUVENILE LECTURE.

The third and concluding Juvenile Lecture of the present session was delivered on Wednesday afternoon, January 16th, by MRS. JULIA W. HENSHAW, F.R.G.S., Croix de Guerre, the subject being "Among the Selkirk Mountains of Canada (with Ice-axe and Camera)." The RIGHT HON. LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, presided.

The lecture was fully illustrated by a magnificent collection of hand-painted lantern slides, which faithfully depicted the gorgeous masses of colour and the awe-inspiring grandeur of the scenery in that part of the Dominion—British Columbia—where both the Selkirk and Rocky Mountains reach their maximum of elevation. Mrs. Henshaw gave an account of the journey she and her companions made in 1896, when history making in the Rocky mountains was in its infancy, and very few men had followed the early footsteps of such intrepid wayfarers as David Thomson, whose record in Canada was unequalled, dominating as it did the history of the Columbia-Kootenay Valley; Sir George Simpson, Captain John Palliser, David Douglas, and Simon Fraser—those grand old pioneers who first blazed the trails and navigated the waterways of British Columbia.

The scenes shown on the screen included magnificent views in colour and monotone of the Bow River, Castle Mountain,

Vermilion and Sinclair Passes, Mount Whymper, Mount Ball and other glacier-covered mountain ranges; Lower Columbia Lake, the Oregon (now called the Columbia) River, the longest and largest waterway in Western Canada, whose source in the mountains was first discovered by David Thomson in 1808; the Crown Circular Road, a great loop of some 500 miles—a marvellous piece of mountain engineering, where man had conquered nature; as well as the glorious Alpine region, with its virgin peaks, unknown, un-named, and unclimbed. She also referred to the ochre beds and to the fact that long before the advent of the white man the Kootenay Indians had used these colourings to decorate their teepees with weird designs and to adorn their bodies for battle or religious ceremonial. Views of the natural monuments regarded by the Indians as the dwelling place of the Great Spirit, and of the holy ground visited by the young Kootenay Indians on attaining manhood in order to keep vigil, as the Christian Knights did of old, were also shown and explained.

In some places, Mrs. Henshaw said, the valleys were literally blue with flowers, so blue that one felt as if a piece of Heaven had dropped down upon the earth. Among the numerous slides thrown upon the screen were coloured photographs of Indian pipe, that degenerate member of the beautiful family of heaths; the timid winter green, called by Asa Gray "A single delight;" snow lilies, with blooms as white as snow itself, which push their way through the snow in early spring; magenta calypsos; purple dragon heads; scarlet columbines; rose-red bergamot; spangled blue flax; harebells; vetches of every hue; hawk-weeds; ragworts; arnicas; golden rod; wild roses; honeysuckle; gaillardias; waxen-belled rhododendrons; pale green feathery Lyall's larches; flaming cotton-woods; a species of cyclamen; anemones; all the genus of blueberry, bilberry and cranberry; red osier dogwood, arrow wood, capberry and other fiery fruited shrubs. Pictures of birds and animals plentiful in that region were shown and described, including brown, black, and grizzly bears; marmots; moose; elk; wapiti; mountain sheep; and mountain goats which closely resemble the species in the Himalayas. She remarked how strange it was that two so widely different animals as the moose and the prairie chicken should be fond of dancing, and said it was not at all an uncommon sight to see a prairie chicken perform a first-class shimmy dance. The Indian children in their own native dances had cleverly imitated the bird.

When their journey along the Happy Valley and through the north-western prairie lands had ended, Mrs. Henshaw said they had visions of the great agricultural possibilities of the country, and pictured how it would look in the years to come. Much of the vision had been realised to-day; but

"Thank God, there is always a land of Beyond
For those who are true to the trail,
A vision to seek, a beckoning peak,
A farness that never will fail."

The Chairman moved a hearty vote of thanks to Mrs. Henshaw for her admirable lecture and for the beautiful pictures which she had shown. The scenery was the grandest in the whole world, and he knew of no finer sight than the scene seen at the break of dawn over the Rocky Mountains. It was a sight which remained in one's mind for a great many years, and he hoped some of the younger members of the audience would in course of time be able to see for themselves the glories and wonders of Canada, one of the most splendid jewels in the British Crown.

Mrs. Henshaw acknowledged the vote of thanks and the meeting then concluded.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

COCOA CULTIVATION IN THE BRITISH TROPICAL COLONIES.

By Samuel Henry Davies, M.Sc., F.I.C.

Lecture I.—*Delivered November 12th*, 1923.

The cocoa tree is a native of the tropical forest and is probably derived from the upper basin of the Orinoco and Amazon. This cannot be stated with any certainty because the Indians had cultivated the tree for centuries before the Spanish Conquest and the seed had been widely scattered by birds or monkeys in the neighbouring forests. The first Spanish settlers carried the seed from Central America and the Spanish Main to Jamaica, Trinidad and the lesser Antilles. Notably in Jamaica

a large number of "cocoa walks" were found by the first British Colonists at the time of the Commonwealth and it is on record that a choice variety of bean was planted by the Spaniards in Trinidad in Elizabethan times. A disaster overtook all the Island plantations in 1727, described as a "blast," variously interpreted to mean either a hurricane or a destructive blight. Thirty years later a hardier variety from the Venezuelan coast was cultivated in Trinidad.

The fact of its forest origin is important, if we would understand the climatic conditions and the several precautions required in establishing a cocoa cultivation. Thus, the tree is sensitive to cold and drought, it cannot flourish where the temperature drops below 65° Fahr., and grows best in a humid atmosphere, with a mean temperature of 75° to 78° Fahr. This serves to define the range of latitude within which it can be profitably cultivated — some 20° North to 20° south of the Equator. Cocoa can be grown to advantage from sea level to 1,000 feet and in equatorial regions may give good crops up to 2,000 feet, in contrast with coffee and tea which flourish at much greater altitudes. The rainfall should be well distributed, the exact requirements naturally depending on the water level and nature of the soil, and the humidity of the air. A rainfall of from 60 to 120 inches is advantageous, with extreme limits of 45 to 200 inches.

The Tree.

The only species of commercial importance is the Theobroma Cacao of Linnaeus. It grows quickly, and under favourable conditions, reaches its full height of 20 to 25 feet in a dozen years. But in deep alluvial soil, on Trinidad estates, we may find trees planted in slavery times 40 feet and more in height. The extreme case is to be found on the Amazon, where the native does not willingly interfere with the ways of Providence, and there I have seen it shooting up in the forest to amazing heights.

The tree branches about 4 feet from the ground—from 3 to 5 branches is the rule. If allowed to grow freely it would form a dense network of branches; suckers would spring up and form a secondary system of branches. In the early stages the large oval leaves are a beautiful olive brown shading to pink, soft and transparent and hanging downwards, but they gradually thicken, changing to light green and finally to leaves of a full green tint and leathery texture. A curious feature of the cocoa leaf is the double articulation at either end of the leaf stalk, which forms a universal joint and makes it possible for the leaf to rotate in any direction, so that the upper surface always faces the light.

The flower buds appear on the trunk and main branches, often forming in the axiles of leaves but not developing until the leaves have dropped off at that point. The full beauty of the cocoa tree is displayed after the rains. Then may be seen in their framework of leaves (brown shading to green) clusters of tiny cream or pink blossoms studding the rough trunk, with more blossom scattered along the branches—tens of thousands of flowers of which only 2 or 3 in a thousand will fructify. Alongside the blossom we may find tiny cucumber-like pods, together with pods at every stage up to the full grown fruit. One tree may carry green pods ripening to lemon yellow, while a neighbouring tree may bear splashed crimson pods ripening to an orange vermilion. While there are usually two main crops dependant on the rainy season, a scattering of flowers or pods can be found for ten or eleven months in the year. The tree is never wholly bare of leaves. It may bear blossom at the third year, but it should not be allowed to bear fruit until the fourth or fifth year. It should be in full bearing at the tenth year or earlier, if conditions are favourable.

How the flower is fertilised has long been a vexed question, as the form of flower would seem to exclude self pollination. There is strong evidence of cross fertilisation on any plantation where two or more varieties are grown in neighbouring plots. The pollen might be carried by wind or by wasps, bees or other winged insects. Dr. von Faber of Java has shown, however, that self pollination is the rule, but that pollen can be carried by a breeze to flowers of a neighbouring tree with interlocked branches.

Varieties.

We have, then, just the one species of Theobroma of commercial importance, easily recognisable as one and the same tree in Ceylon, on the Gold Coast or the Antilles. It is only when we come to examine the fruit and seeds (usually termed pods and beans) that we are faced with sharp distinctions suggesting definite

varieties. The finest type is the *Criollo*. Its name suggests that it is the native or creole Venezuelan type. Cultivated in the fertile valleys of the Venezuelan coast ("The Spanish Main") it was the first variety to be planted on the Islands, and from Trinidad was conveyed in 1834 to Ceylon. Here to this day may be found pure strains of Criollo cocoa, known on the London market as "old red cocoa" of Ceylon. The Criollo type is distinguished by a knobby irregularly shaped pod, broad at the stalk end often tapering to a decided point. The husk is comparatively soft and thin; there are ten distinct furrows, five deeper than the rest. The typical pod is red in colour. Of greater interest is the nature of the bean. The contents are white or pale pink in colour; much sweeter and less astringent in taste than any other variety. For this reason the Criollo bean is specially prized in the manufacture of the choicest chocolate.

We can clearly distinguish between this and the *Forastero* type (*i.e.*, foreign to Venezuela) but the Forastero shades off almost imperceptibly into the least valued type, sometimes classified as a separate variety, the Calabacillo (*i.e.*, the shape of a calabash). Under the name Forastero are classed the most widely cultivated kinds; they are distinctly hardier in habit than Criollo, giving an earlier first crop and heavier subsequent crops. One of the finest types of Forastero bears large pods, 9 to 10 inches long with a constriction at the stalk end and a warty surface. This is the *Cundeamor*. Near akin to this is the *Liso* or Trinidad Forastero, with a similar pod but without the constriction; the shorter, melon-shaped pod without constriction is known as the *Amelonado*. This type is widely cultivated in West Africa and elsewhere.

Each type occurs both as red and yellow fruit. All kinds of Forastero pods possess thick, hard husks but the furrows are not so deep, nor the ridges so pronounced as in the Criollo. The beans are decidedly flatter, the colour of the fresh contents varies from a light purple to a deep violet; this colour is always associated with an astringent taste. The poorest types of Forastero, conveniently classed as *Calabacillo*, bear a rounded pod, about 6 inches long with smooth surface scarcely lined with furrows. The beans are flatter and smaller than those just described, deep purple or slaty purple in hue and harshly astringent in taste. Any of the Forastero types hybridise and improve in the following generation when planted alongside Criollo trees.

Forming a Plantation.

In establishing a plantation it is most probable that one of the better Forastero types would be selected. The small yield of the Criollo and its low resistance to disease prevents its exploitation on a large scale. The seed selected can best be planted "at the stake" *i.e.*, in the field; the rule being to plant three seeds and allow the strongest seedling to survive. The mortality of the seedlings is heavy—30 or 40 per cent. may succumb, so that it is customary to raise supplies in a nursery protected by a light cover of palm leaves. The pots are conveniently made of bamboo joints which are split open with a stroke of the cutlass on transplanting.

In selecting a site for a cocoa plantation we should, as already noted, seek a humid climate, a rainfall not excessive but well distributed, where there is no likelihood of prolonged drought nor quick changes of temperature. Many kinds of soil have proved capable of growing healthy prolific trees; best of all, rich alluvial loam, with free drainage. Soil soaked in brine or otherwise water-logged is quite unsuitable. The black vegetable mould of virgin forest land is especially esteemed and so are volcanic soils, rich in potash and phosphates.

The clearing of forest land is a formidable undertaking. Once the trunks are removed, the branches and stumps are burnt and the ashes forked in. Shade trees are planted if required and temporary shade for the seedlings. The crowns of the hills must on no account be stripped; they are left in forest to prevent the wash out of soil by the tropical deluge. Broad belts of trees are left between the clearings to act as wind-screens, for the cocoa leaf is singularly sensitive to high wind. In open country close wind-breaks are planted, choosing trees, if possible, of economic value, such as the Hevea or other rubber trees, the bread-fruit, mango, guava or other fruit trees, or even selected timber trees. Good drainage of the plots is absolutely essential; the usual plan being to run open drains into streams or ravines. Where the soil is loose a creeping undergrowth is necessary to hold up the sides of the drain. Catch crops are quickly established to shield the soil from direct sunshine and to provide the

necessary temporary shade for the cocoa seedling. Tannias, cassava, chillies and pigeon pea are recommended. The destruction of organic matter (commonly described as humus) by the action of tropical sunshine on the bare soil is extraordinary. Bananas are universally planted in Jamaica and wherever there is a ready market for the fruit. Their broad leaves efficiently protect the young cocoa. Where conditions are favourable a crop of bananas may be reaped each year for 5 or 6 years, or until the cocoa trees cover the ground. Only when the catch crops are established and the land drained can the cocoa seedling be planted. The best variety of seed to select for propagation can only be determined by a careful study of trees in the locality, but in all cases (as will be shown later) it is important to plant ripe seed from the most prolific and vigorous trees.

It has been the practice in most of our colonies to plant *permanent* shade trees, but this has not been the case in Jamaica, Grenada, St. Lucia or Dominica where the cocoa is grown in volcanic mountainous districts and for the most part in valleys sheltered by high ridges. Two of the Erythrinas are commonly grown for shade in Trinidad and the neighbouring mainland; the variety grown on the hills (*Erythrina umbrosa*) blazes out in early spring into flame-coloured blossom. The favourite shade trees—Erythrinas, Samans, and others—are all leguminous trees, acceptable because the nitrogen-fixing bacteria of their root nodules arrest the exhaustion of the soil, while their flowers, pods and leaves supply a rich mulch.

A network of fibrous roots holds together the soil of an old cultivation and leaves little room for the growth of weeds, but in younger plots the practice has grown up of clearing the weeds two or three times a year and lightly forking them into the soil, with or without lime. Mr. Joseph Jones, of the Agricultural Station, Dominica, has established beyond doubt the great advantage of heavy mulching with grass, weeds and leaves. In this way he obtained better and more profitable yields than with dressings of a complete artificial manure, up to 80 per cent. in excess of the unmanured plot. It is not customary to carry much live stock on a cocoa estate, but the manure from draught oxen, horses, mules and pigs, is of special value under tropical conditions where the decomposition and wastage of humus is extremely rapid and where the building up of a spongy soil is necessary to retain moisture. Green mulching may be regarded as supplementary to pen manure. The vegetable mulch may be greatly enriched by forking in a crop of any low-growing form of leguminous plant.

Manuring.—The accumulated experience of field trials, continued for at least twenty years, shows that the soil nutrients required by the cocoa tree are similar in character to those required by our fruit trees. Elaborate calculations have been made of the quantity of each nutrient carried off annually in the crop, but such calculations are of small value in determining the quality and quantity of manure required. Direct experiment is necessary in the field. If this is true in our climate, how much more in a climate where the breakdown of rotting vegetation to form available plant material and even the weathering of soil takes place with great rapidity. It is often found unnecessary to supplement the available supplies of nitrogen, phosphate and potash, for many years in succession. Supplies of *nitrogen* are well conveyed in the form of sulphate of ammonia, dried blood, guano or cotton seed meal. On most soils nitrate of soda does not react so well as the ammonium salt. Where supplies of wood ashes fail, *potash* is best given as the sulphate. *Phosphate*, in the form of basic slag, reacts favourably on the trees for at least three seasons and is widely applied. A dressing of *lime* or ground chalk has proved invaluable on most estates.

Forking.—In the absence of permanent shade trees, forking or light hoeing of the soil becomes specially important with a view to retaining humus and arresting evaporation. This should naturally be done at the beginning of the dry season.

Pruning.—I can only touch lightly on pruning, a subject dear to the heart of every planter. Johnson defines the main object of pruning as the production of symmetrical trees with the maximum quantity of fruiting branches; the admission of air and light to all parts of the tree; the removal of gormandising suckers from the main stem, and, generally, to encourage a spreading habit which enables the fruit to be more readily harvested. The severe pruning of former days has been replaced by light pruning at frequent intervals.

For a detailed account of the methods of cultivation, reference must be made to three

admirable text books which have been drawn upon in preparing this address:—*Cocoa*, by Dr. Van Hall of the Institute at Buitenzorg, Java; *Cacao, its Cultivation and Curing*, by the late J. H. Hart of Trinidad; *Cocoa its Cultivation and Preparation*, an Imperial Institute Handbook, by W. H. Johnson, formerly of the Gold Coast and South Nigeria. For information on diseases of the cocoa tree see W. Nowell's work, "Diseases of Crop Plants of the Lesser Antilles," recently published by the West India Committee.

Harvesting the Crop.—When the pods are ripe, those on the trunk and lower branches are easily detached by a clean cut with the universal tool of the country, the *machete* or cutlass. The branches are too brittle to allow the pickers to climb, so that fruit from the upper branches is cut down by a hooked knife, attached to a bamboo pole, serving equally well for a push or pull cut. Great care is required to protect the cushion from which the pod springs; once damaged no further flowering can take place at that point.

Breaking.—The ripe pods are collected in heaps and broken by a slash with a cutlass, which penetrates partly through the husk, the pod being snapped across by hand. The beans should be taken out by hand and separated from the placenta or "heart" which is thrown to one side, along with the husk. Each pod contains from 30 to 40 beans. The beans and the white pectinous mass of pulp surrounding them are then placed in clean baskets, covered by banana leaves and carried to the fermenting house.

Yield.—Three cwt. of dried cocoa beans to the acre may be considered an average yield for estates good and bad. Given a planting distance of 12 feet this only represents an average of 14 pods a tree, or 1.2 lbs. of dried cocoa. Average yields of 5 to 6 cwts. to the acre are attainable on fertile soils, and double this on selected plots. Thus Carl de Verteuil of La Vega, one of the most experienced planters in Trinidad, obtains crops of 12½ bags (or 170 lbs.) per 1,000 trees, or approximately 5¼ cwt. dried cocoa to the acre. One splendid old tree, used for propagating at La Vega, yielded 670 pods in 1917 (55 lbs. dried cocoa); 359 pods being collected at a single picking.

Diseases.—Of the many mammals, insects and fungi that prey on the cocoa tree we can only refer to the more important.

Fungi.—The *brown root* disease of Ceylon and West Africa can often be extirpated by re-draining the land, after burning infected roots and disinfecting the soil. A more wide-spread fungoid disease, found both east and west, is the well known *canker* (*Phytophthera faberi*) attacking trunk and branches and giving rise to the *black rot* of pods in the West Indies, identical with *brown rot* of Ceylon. Moist spots appear on the trunk which darken and exude gum. The fungus may penetrate into the wood giving reddish patches. At a later stage the whole patch can be cut out with a knife. It is a curious fact that *canker* and *black rot* are seldom found together on one and the same tree. In the Antilles, a vigorous fight is maintained against *die-back*, the cocoa *Diplodia*, a deadly fungus found everywhere. It first attacks the extremities of the branches and, if left alone, will strip the tree of its leaves before killing it. It often follows an attack of thrips.

Insects.—Of insects, probably the group of *borers* is the most deadly, more particularly the larvae of beetles. Beetle traps are employed with some success on plantations. In Ceylon a well known *helopeltis* attacks both twigs and pods. This has been exterminated in several cases by introducing nests of the black ant. In the West Indies a most dangerous insect is the small cocoa thrips, which strips the leaves and may even kill the tree.

Side by side with the direct attack on disease attention has been concentrated, in recent years, on promoting the vigorous growth of the tree by enriching the soil and clearing it of weeds. This has proved remarkably successful. In Dominica I have seen a young plantation, where trees were failing and diseased, restored to full health by careful tillage of the soil and provision of adequate cover from sun and wind; all gaps being filled with tephrosia or pigeon pea. Cocoa thrips and, in some cases, *canker* can best be fought on these lines. On the other hand *canker* and *black rot* are often cured by removing excessive shade and letting in air. The obvious line of attack on the borers is to cut out all dead branches and diseased limbs; to burn the refuse and tar the wounds. This will also restrict the breeding ground of the *die-back* fungus. Other obvious precautions include the removal of rotting trunks of trees from the site, and sprinkling the heaps of pod husks with lime, preferably quick lime, before burying them in shallow trenches.

Along with these methods of sanitation spraying must not be neglected, preferably with Bordeaux mixture, sprayed on the leaves and immature pods to protect them from fungoid disease and to kill any existing fungus.

Mammals.—Rats and squirrels are a pest on the Gold Coast and elsewhere. One mistaken attempt to exterminate rats had extraordinary consequences in Jamaica. Fifty years ago a worthy Governor introduced a big species of rat to eat up the native rats, which it did with avidity, and then fed on the fat of the land. His successor brought mongoose from the east, which, after cleaning out the rats, raided hen roosts and insectivorous birds' nests. In the absence of birds, ticks and other insects became a serious scourge, attacking all and sundry, even infesting and destroying the mongoose. The birds are now coming into their kingdom, and the balance of nature is being restored.

AGRICULTURAL DEPARTMENTS.

The industry is greatly indebted to the agricultural departments of the several Colonies. It has benefited by their active propaganda in favour of more scientific methods of culture, conducted both by demonstrations on the plantations and by extended field trials. The Trinidad Department, under the Directorship of Mr. W. G. Freeman, took the bold course of purchasing a derelict plantation—the River Estate—which it has developed into a valuable property. Here the more urgent problems of the industry are being solved by carefully devised experiments. Let us discuss a few of them to illustrate the valuable work done by the Departments.

(1) *Planting Distance.*—Plots have been established with trees planted at all distances from 6 to 18 feet. The results obtained show that closer planting produces earlier and heavier yields, and justifies the modern practice of planting at 10 to 12 feet, rather than at 14 or 16 feet intervals. Unlike the orange or lime tree it is no disadvantage for the branches to interlock slightly, giving that partial shade which favours good bearing.

(2) *Permanent Shade.*—For years the practice of shading cocoa with the quick growing Erythrina has been the subject of hot debate amongst planters. It has been definitely established at River Estate that full shade, as practised in the Island, with an Erythrina at 28-30 feet intervals, encourages *canker* and *black rot.* A condition of partial shade, however, *e.g.* an Erythrina planted every fourth row, at 56ft. intervals, favours heavier crops than are given by unshaded trees. As this idea wins acceptance, planters are beginning to cut out alternate shade trees in the older cultivations, a most difficult undertaking.

(3) *Bearing Capacity.*—Individual records of 1300 trees show that the annual crop of pods varies enormously. Thus two neighbouring trees of the same age and variety, over an eight year period, gave an average yearly output of 54 pods and 2½ pods respectively. Special manurial treatment has an all-round beneficial effect but does not convert poor or medium-bearing trees into good bearers. Heavy bearing appears to be a matter of heredity, hence the great importance of selecting seed for propagation. This fact was not taken into account in the older manurial trials, on small plots, and renders them of comparatively little value. All manurial trials are now preceded by recording details of the growth of the tree and crop yielded for some years under natural conditions. Trials are being made to eliminate poor bearers by cutting them down two feet from the ground, allowing a sucker to shoot up from the ground and budding from a heavily bearing tree.

(4) *Budded and Grafted Plants.*—Grafting by approach is considered too difficult an operation for estate work; moreover there is no chance of renewal if it fails. Patch-budding is simpler and patch-budding at the stake proves more certain than budding in the nursery. Judging, however, from the latest published results it seems probable that seedlings will prove earlier and heavier bearers than budded stock. Elsewhere, budding a fine Criollo variety on a hardy Forastero stock has given good results.

Enough has been said to indicate the fruitful lines of research undertaken by scientific advisers on Agriculture in the Colonies. They deserve all praise for revivifying old, introducing new industries and equipping defence forces to arrest the ravages of plant diseases. It is encouraging to find that the scientific equipment of the Colonies has just been strengthened by founding a tropical Agricultural College in Trinidad. The Staff of the Imperial Department of Agriculture has been absorbed by the College, and the Commissioner, Sir Francis Watts, has become its first principal.

It is under the control of a Board of Governors, sitting in London. The College gives unrivalled opportunities for research on the unsolved problems of cocoa cultivation, while training the coming race of planters and researchers.

It has already attracted post-graduate students from distant countries.

CURING THE BEAN.

(1) *Fermenting.*—A variety of receptacles are employed for the process of "sweating" or fermenting the bean. The simplest plan is to be found in Ceylon, where the mass is heaped on the floor, covered with banana leaves and stirred from time to time. In West African Colonies, floors, barrels, packing-cases, and properly constructed boxes are made use of. The tanks or "sweat" boxes used in Trinidad are large pitch-pine structures (*e.g.* 6 x 6 x 3 feet), often built in sets of six, and embedded in concrete. Each box can carry the contents of 40,000 pods, the equivalent of 30 cwt. of dried cocoa. The solid wood bottom of the tank is pierced with holes, and supports a wooden grating, on which the mass stands. It is customary to turn the fermenting cocoa from one box to another on the second, fourth and sixth days, turning it out to dry on the eighth day, but some planters prefer a six day fermentation. The method I would more closely describe is based on that long practised in Grenada, and recommended for adoption in West Africa. The box is smaller, carrying the contents of 8,000 to 16,000 pods, made of 1½ inch timber, fastened with copper nails, it carries a false bottom perforated with a number of holes. The cocoa is covered with banana leaves and a perforated lid closes the box, the drainings or "sweatings" run out through holes in the under space. It will be seen that this arrangement makes it possible to control the aeration of the mass. The boxes are arranged in rows in a low "horse." The floor should be finished in smooth cement, sloping to a gutter and both floor and boxes should be frequently swilled out. We discuss later the exact nature of the fermentation process.

(2) *Drying.*—From the "sweat" house comes a mass of hot beans, still coated with a residue of brown, slimy pulp. In Ceylon, the beans are washed at this stage to give a clean shell and bright colour. In the other Colonies the cocoa is turned out to dry without further treatment.

The Trinidad Government has just legislated against the practice of rubbing the damp beans in red ochre or red clay to impart a uniform appearance to the shell.

Drying in the sun and wind is still the rule where the climate allows, but an artificial drier is a valuable insurance against loss in the rainy season. The older sun-driers take the form of large cement or paved courts, called barbecues. The favourite sun-drier in Trinidad is a fixed wooden floor with a sliding roof. When the floor is covered, drying is sometimes continued by means of hot air or hot-water pipes, running under the drying floor. In Ceylon, a hot-air apparatus of a simple character is universally employed for drying cocoa in the rainy season. Air from a stove is drawn over the beans by a powerful fan, in a cheaply constructed drying house. The smaller estates on the Islands use wooden trays on wheels, running out on rails from the shelter of the drying house. The beans are raked over regularly; a slow and uniform drying results. The beans are heaped the first night, when they are still damp enough to allow fermentation to take place. Before the mucilage is dry, the beans are often rubbed by hand or polished by "dancing" with bare feet, to improve the appearance. This curious process is seen to advantage in my slides.

Drying by artificial heat has to be carefully adjusted to avoid quick and uneven drying. A favourite form of drier is the "Guardiola," consisting of a horizontal rotating drum, fed with hot air through a system of tubes. It is best adapted for completing the drying, after the beans have been exposed to the sun for a day or two. This is only one of a variety of mechanically operated driers.

LECTURE II.—*Delivered November* 19*th*, 1923.

We may now briefly consider the position and prospects of the cocoa industry in our several Colonies.

Trinidad.—It has long been recognised that Trinidad has an almost ideal climate and soil for the culture of cocoa. The fact that the island lies well outside the usual track of hurricanes gives the planter confidence. Trinidad lies 10° North of the equator with an average rainfall ranging from 65 inches on the coast to 100 in the hills, and a humid atmosphere. The best plantations are to be found in well protected and well drained valleys, with deep alluvial soil, covered with

a rich deposit of mould. Cocoa also grows well in a brown loam, known as chocolate soil. It is not considered remunerative to plant above 800 or 1,000 feet. The ubiquitous Erythrina, miscalled the Immortelle, towers high above the cocoa groves; its light foliage gives an agreeable shade, in contrast to the scorching sunshine of the sugar fields. The discovery of extensive oil fields underlying the estates has enriched some of the planters, but should not lead to the destruction of many trees. The presence of a large East Indian population makes it possible to secure good agricultural labourers, willing to give a full week's work, and this in turn reacts on the negro. Many of the estates have been planted under a contract system. The contractor is bound to plant a given number of trees and is allowed to take catch crops for his own use, usually for a four year period, at the end of which he cleans the land and hands over the established plantation. Many planters now prefer to avoid the obvious risks involved in such a system and employ direct labour, which is always paid by the task. The plantations contain every variety of Forastero (including Cundeamor, Liso and Amelonado), but only isolated survivors of the older Criollo culture.

The relative importance of the British West Indian Islands as cocoa producers may be shown by taking the average of the 1921 and 1922 crops. They are quoted in short tons (2,000 lbs.).

Trinidad	36,000
Grenada	4,500
Jamaica	4,200
St. Lucia	750
Dominica	350

It will be seen that only the more mountainous islands, with rich volcanic soil, figure in the list.

Grenada, the beautiful Spice Island, is mainly given over to the cultivation of cocoa and nutmeg, on plantations rarely exceeding 50 acres. Here cocoa is grown without shade, and nowhere is the tillage and manuring of the soil better understood, nor the trees better cared for. Close planting is the rule and the yield per acre is unusually high. Sheep or cattle are kept to provide pen manure. A fifth of each plantation is reserved for pasture and arable. It is claimed that the absence of shade trees saves much expense while the cocoa comes earlier into bearing and gives a higher yield.

Jamaica.—The present culture has only been established 50 years and has grown with the rapid extension of the banana trade. Cocoa has been extensively inter-cropped with bananas; this applies more particularly to the sheltered valleys north and south of the Blue Mountains. Hurricanes and strong "Northers" have played havoc with the plantations in Jamaica as well as in Dominica and St. Lucia.

Ceylon.—Until Sir Arthur Gordon opened up the Montserrat district, in 1868, only some 7,000 acres were planted in cocoa. The planting was rapidly developed by resident proprietors, between 1870 and 1880 at a time when a leaf disease was leading to the wholesale destruction of coffee plantations. No export trade was attempted until 1878. By 1890, the export amounted to 1,000 tons and in 1905 to 3,200 tons. Since that date there has been no marked increase. Over 2,000 estates include cocoa amongst their crops, but the total area in cocoa is only 30,000 acres. All these estates are situated in the moist districts, where the rainfall varies from 75 to 120 inches. Much of the island lies above the 2,000 feet level and therefore is adapted for tea culture rather than for cocoa. When the Criollo trees of the original strain were attacked by helopeltis and canker, Forastero seed was planted, in the expectation that this type would prove more resistant, but the diseases are still rampant and tend to restrict the crop. Bananas are not used for shade, the dadap (Erythrina lithosperma) is preferred both for temporary and permanent shade. Cocoa and Hevea (rubber) are often planted in alternate rows at distances of 20 feet.

Nigeria.—Cocoa is said to be grown but not cultivated in Southern Nigeria. We learn from the same source, that it grows in spite of the mishandling to which it is subjected.* The culture is extending from the West province to the Central Province. Climate and rainfall are entirely suitable in the rain forest belt. The native does not grow cocoa under shade. His primitive methods of culture involve pruning with a cutlass, and manuring the tree with its dead leaves and weeds. In pre-war times when the native could produce at 10s. per cwt. and sell at 40s. to 50s., it was difficult to persuade him to cultivate and cure his cocoa properly, but lower prices and the increased cost of labour seem likely to provide

* Trade relations between Canada and Nigeria. Report of 1920.

the necessary stimulus. The Amelonado type of cocoa is grown; the quality of the bean is probably as good as that of the Gold Coast but it lacks proper curing and grading for market. The able governor, Sir Hugh Clifford, and Mr. O. T. Faulkner, Director of Agriculture, are alive to the importance of these factors in securing a proper place for Nigerian cocoa, in the world markets. Small co-operative fermenteries, equipped with the simplest of appliances, are being set up and these will doubtless have an educative effect. The crop has increased by leaps and bounds and exceeded 30,000 tons in 1922.

Gold Coast.—In 1918 to 1919 Mr. W. S. Tudhope, Director of Agriculture, undertook a journey of 2,000 miles through the cocoa districts, and his report presents a vivid picture of the present condition of the industry. In the course of 20 years the output of cocoa grew from a single bag in 1891 to 35,000 tons in 1911, when it eclipsed that of any single country. In 1919, the export reached the unprecedented figure of 176,000 tons, valued at 8½ million sterling, a figure swollen by part of the 1918 crop, held back for lack of shipping facilities. So remarkable a growth of an entirely new industry can have no parallel in the history of the negro race.

The rapid expansion of the culture on the Gold Coast, where the tree is grown by the native in small holdings, has often been compared with the relatively slow development in the Cameroons, where big estates were laid out under scientific control.

Mr. Tudhope points out that the closely planted trees are beginning to deteriorate at 20 years of age. Diseases are rampant, both insectivorous and fungoid. There is a serious increase of *brown pod* disease (phytophthera), and *thread blight*. When a farm is badly attacked, it is the universal practice to abandon it, and let the intervening bush smother the trees. After two or three years the plot is cleaned up, with more or less satisfactory results. In any case the farmers tend to abandon the older farms and carve out new plots from virgin forest. Mr. Tudhope views the wholesale slaughter of forests with alarm, in a country where the rainfall (near the coast) is only 45 inches. The railway tapping the cocoa districts has been pushed up country and now extends 67 miles from Accra, the cocoa port. A time will come when low prices, increased cost of labour, and heavier charges for freight will force the farmer to remain on his plot and enrich the soil by manuring and proper tillage. The agricultural officers at Aburi and elsewhere are making a bold stand in favour of better methods of culture and curing. They have succeeded beyond expectation in persuading the farmer to ferment his cocoa. Motor traction is taking the place of head loads and the cumbrous barrels, but these are still to be met with on the up country roads. The economic position of the industry was badly shaken by war conditions. The restriction of shipping nearly caused its collapse, coupled with the control of prices in 1918. The relative values assigned by the food controller at the time were: Ceylon 100s., Trinidad 90s., Grenada and other West Indian sorts 85s., and British West African 65s. Then came the years of soaring prices, followed, in 1920, by a sudden crash. In the course of a year, Accra cocoa fell from 130s. to 42s. cwt. The price offered to the farmer was so trifling that he left his pods to rot on the trees, thus adding more breeding grounds for fungoid disease.

Everywhere, to-day, with the exception of certain Ceylon estates, the planter is faced with an impossible situation; owing to the low prices prevailing he can no longer produce cocoa at a profit.

World Production and Consumption.

Since the beginning of the century, the world's production of cocoa has almost quadrupled, and the consumption has more than kept pace with it. The figures are:—

	Production.	*Consumption.*
1900 ..	102,000 tons.	100,000 tons.
1922 ..	374,000 „	411,000 „

It will be seen that the increase is largely met by the West African crop.

The Imports of cocoa into the chief-consuming countries in 1922, may be compared with those of a pre-war year, 1913. Although not accounting for re-exports, these figures give an indication of the rapid increase in the quantity of cocoa consumed.

Imports.

	1913. metric tons	1922. metric tons
U.S.A.	67,600	150,700
Germany	51,000	84,000
United Kingdom	27,500	51,300
France	27,700	38,500
Holland	30,000	36,000

APPENDIX.—NOTE ON THE FERMENTATION PROCESS.

To understand the nature of the process we must study the composition of the sweet pulp that surrounds the beans. The pulp, by the way, possesses a delightful sub-acid flavour. It contains from 8 to 13 per cent. of solid matter of which 5 to 9 consists of sugars, both invert sugar and sucrose. The free acid present is tartaric acid (1 to 2 per cent.) The albuminoids (0.5 to 0.7 per cent.) are present in sufficient quantity to promote the growth of micro-organisms. We have here an ideal medium for an alcoholic and subsequent acetic fermentation. That such spontaneous fermentations take place is evident to the senses and is shown, beyond doubt, by analysing the drainings from the pulp. Here, for instance, is the composition of the first runnings from a fermenting box in Jamaica drawn 15 hours after breaking the pods.

Total solids	5.8	per cent.
Mineral matter	0.5	„
Invert sugar	3.5	„
Pectin	2.0	„
Alcohol	4.9	„
Total Acidity (as Acetic acid)	0.8	„
Volatile acid (as Acetic)	0.6	„

This will serve to illustrate the fundamental changes that have taken place. Remember that the liquor penetrates into the beans which become saturated with the products of fermentation, profoundly affecting their flavour, although the shell membrane is fine enough to prevent any micro-organisms from percolating to the kernel.

The following description is based on a close study of hundreds of fermentations in the West Indies:

The beans and adherent pulp, which are commonly at a temperature of 26 to 28° C. when placed in the box, rapidly become warmer. During the first 24 hours the temperature rises to 35 or 40° C., varying with the position in the box. Within 48 hours it rises to 40-45°C. If the fermentation is continued for 5 or 6 days the temperature will be found to rise to a maximum of 45-50° and maintain this until the 8th or 9th day. Higher temperatures are occasionally noted, but they rarely exceed 53°. If the fermentation is continued for the exceptionally long period of ten to eleven days, as is the custom on certain Trinidad estates, the temperature will fall slightly towards the close. While the process is going on the bean and adherent pulp change from white or pale pink to a rich brown colour; characteristic odours are evolved and a most vigorous fermentation takes place. Although the fermentation is spontaneous, it follows a definite course if the boxes are not infected and the aeration is sufficient. We can distinguish three clear stages. First, a feeble alcoholic fermentation, due to organisms that were growing on the surface of the pod. We always note a strong growth of saccharomyces apiculatus, together with smaller quantities of sacch. anomalus and other "wild" yeasts. This stage lasts about 12 hours. Secondly, as in spontaneous wine fermentation, an enormous development of true saccharomyces occurs exhibiting typical oval and round cells. If the temperature rises normally, no formation of new cells is noted, after the first 48 hours. The alcohol produced soon arrests the growth of saccharomyces apiculatus and the "wild" yeasts. At this stage a quantity of alcoholic liquor drains away. The third stage of fermentation is characterised by a great growth of acetic acid bacteria. In addition to air-borne bacteria, masses of these are conveyed to the boxes by swarms of the little brown "vinegar fly." (Drosophila). They carry the bacteria from their last meal of rotting fruit. The mixing of the mass every second or third day ensures the presence of acetic acid bacteria in every part of the fermenting mass, where both temperature and degree of aeration favour rapid growth. The drainings now consist of dilute vinegar. If the temperature does not rise above 50°, the acetic organisms continue to grow during the remainder of the fermentation. In the rare cases where fermentation is prolonged beyond eight days, a fourth stage is reached with a vigorous growth of spore-bearing bacilli, of the bacillus subtilis type. As fermentation progresses the change of odour is marked. The sweet, fruity and mildly alcoholic odour of the early stage changes, first, to a strongly alcoholic, and then to an ethereal odour suggesting ethyl acetate. Later a strong acetic acid odour supervenes, but this is always accompanied by fruity ethereal components. Finally if the fermentation is prolonged until putrefactive organisms predominate, an odour resembling that of high game is evolved.

Although it seems on the face of it extremely improbable that such a crude process,

in an atmosphere charged with germs, should give a normal sequence of fermentations, yet this is undoubtedly the case. Abnormal fermentations are seldom noted, if the fresh beans are immediately conveyed to the boxes with due regard to cleanliness, if the mass is not diluted by rain in transit, and if the degree of aeration is under control. A cold diluted pulp will favour the growth of moulds and an insufficient air supply the growth of putrefactive bacteria. In either case the process must be stopped at once and the beans dried off.

The conditions allow of the growth of any of the true yeasts derived from the air or from the surface of the husks (provided they can exist at the high temperature of the mass) without any noticeable fluctuation in the character of the product. It would seem, therefore, beside the point to suggest, as Preyer has done, that a specific type of yeast is required to bring about a normal cocoa fermentation. In its earlier stages the process may be likened to a spontaneous wine fermentation, but, whereas the quality of the wine is almost entirely due to the products of fermentation, the quality of the fermented cocoa is dependent on a series of internal chemical changes, although the eventual flavour is modified by the residual products of the pulp fermentation.* Putting on one side some of the more obvious effects of the external fermentation, *e.g.*, the removal of the greater part of the pulp, and the loosening of the seed from its testa (causing it when dry to break up easily into nibs), let us consider more closely the improvement in flavour and colour. The primary effect of fermentation is to kill the seed, a change accompanied by the destruction of plant tissue, the liberation of enzymes, and the beginning of chemical activity. Sack, in Surinam, has shown that exposure to a temperature of 44°C. for 6 hours is sufficient to kill the embryo. This temperature is commonly reached on the 3rd or 4th day and coincides with the development of enzyme activity, while the optimum temperature for the enzymes 45°-60°C. is reached in the latter stages. It may be recalled that the oxidising enzyme (*oxidase*) is only destroyed at 75°C.

Our knowledge of the cocoa enzymes is derived from the work of Oscar Loew of Porto Rico, and Harvey Brill of Manila. Brill finds a greater number of enzymes in the pulp than in the fresh bean, but these percolate into the bean during the process. He finds no evidence of fat-splitting nor glucoside-splitting enzymes, but he finds the proteolytic enzymes (casease and protease), and large quantities of oxidase in the bean and pulp. Invertase, diastase, and raffinase are present in the pulp and fermented bean. How far can we trace the effect of their activities on the constituents of the bean ? The cocoa butter is hardly affected, but the albuminoids are attacked to a slight extent, as shown by a decrease of proteid and an increase of the amino acids. The total loss of dry material is trifling. Although the evidence has been criticised, it will be convenient to regard the most important chemical change as the breakdown of a complex glucoside (Schweitzer's cacaonine) into glucose, cocoa-red and theobromine, the white crystalline alkaloid. This presupposes the absorption of oxygen. This, or a similar hydrolysis occurs, but the reaction is only completed when the bean is heated to the roasting point. Schweitzer's equation cannot be accepted in its original form, becuase it does not account for the production of the essential oil. By distillation of many cwts. of roasted cocoa nibs it proved possible to isolate enough essential oil to determine its composition. It has an extremely powerful odour and is undoubtedly the true aromatic body. As it constitutes less than 1 part in 100,000 of the bean, it is not surprising that it long escaped the notice of chemists. The liberation of cocoa-red accounts for the marked change of colour. It exists in two forms, a bitter soluble substance which readily oxidises during fermentation into a reddish brown, insoluble and therefore tasteless form. The series of reactions described above would account for (a) the reduction of astringency, (b) the increased sweetness, (c) the production of aroma and (d) the change of colour. While much work remains to be done on the problem it is clear that the development of fine flavour, aroma and colour, owes less to the direct products of fermentation, than to the products of enzyme activity. Two or three days' fermentation is sufficient to complete the desired change in flavour in the fine Criollo bean, whereas a full 8 or 9 days is commonly required with the Amelonado type. Six days is the standard time in West Africa.

* These products are not entirely removed by roasting; when roasted nibs are steam distilled, small quantities of ethyl acetate, propionate and butyrate are found in the distillate.

FOREST RESOURCES OF CHILE.

Amongst the many natural resources of Chile due prominence must be given to its forests. According to the annual report* on the financial and industrial conditions in Chile, by H.M. Consul-General at Valparaiso, the Southern zone is practically covered with forests, the most important being found from latitude 37° to 44°. The area covered is calculated at 75,000 sq. miles, which corresponds to approximately 26 per cent. of the total area of the country. There are considerable tracts of forest land beyond these limits, but the timber, both in quality and quantity, is not so good. Amongst the principal classes of timber exploited commercially may be mentioned rauli, laurel, rdal, avellano, roble, lanque, corque, manio, auce, etc.

Rauli (*Nathofagus procera*) is one of the most important classes of timber handled. It abounds in the provinces of Cautin and Malleco. The wood is of red colour, veined, medium weight, practically free from knots, and dries fairly rapidly. It is used for building and for furniture and is excellent for making staves or barrels. Well selected, it makes a first-class parquet.

Roble Pellin (*Nathofagus obliqua*).—This Chilean red oak is very largely consumed throughout the country and exists between latitudes 38° and 42°. The wood matures very slowly and is used in construction principally for beams and supports. It is also used in the building of barges and for railway sleepers.

Alerce (*Fitzroya Patagonia*) is a gigantic tree which thrives in the swampy districts south of Valdivia. Specimens are found measuring 60 feet high by 5 feet diameter.

The wood has the characteristic of not being affected in the least by moisture, and, indeed, it is largely used in the south of the country for roofing purposes. It is not necessary to replace an alerce roof for 80 or more years.

Coicue (*Nothofagus Dembeyi*) is very abundant in the southern regions and is used for all kinds of construction It is useful for railway sleepers.

Cypress de Cordillera (*Libocedrus Chilensis*) is found from latitude 30° south. It is light in weight and pale yellow in colour, and is used largely for furniture.

Cypress de Guaytecas (*Libocedrus Tetragon*) is found to the south of Valdivia, but abounds in enormous quantities on the different islands between 42° and 46°. The wood is hard and very resistant against water and is used for sleepers in damp regions.

Lingue (*Persea Lingue*) is found from Llanquihue in the south and as far north as Atacama. It is used in construction works, but its principal use is for furniture. It possesses a rich coloured vein which enables it, when varnished, to be made to imitate all classes of fine wood, such as walnut, jacaranda, cedar, etc.

Laurel (*Laurelia Aromatica and Laurelia Senata*).—This tree abounds from latitude 34° to the island of Chiloe. It is used for floorings and ceilings, but selected wood is used for parquet and furniture. Like the lingue it adapts itself to all kinds of varnish.

Litre (*Litre Cautica*) is found throughout the country. It is used for making cart wheels and spokes.

Luma (*Mircongenia Luma*) is obtained in the central and southern zones. Of a red colour, it is exceptionally hard and heavy and is able to withstand enormous strain.

Maniu (*Podocarpus Chilena*) is very durable, aromatic and of yellow colour. It is used for furniture, flooring and construction of masts and spars.

Tique (*Aextoxicum Punctatum*).—This tree is found in the swampy regions of the south. The wood is very durable, and is largely used for naval construction.

Pehuen (*Araucania Imbricata*) is to be found between 37° and 40°. After alerce it is the tallest tree to be obtained in the country. It is used in delicate carpentry work. The fruit produced by this tree (piñon) is reputed to be valuable for medicinal purposes, as is also the bark.

Quillay (*Quillaja Saponaria*) is obtained between Coquimbo and Valdivia. The trunk and branches are used for firewood and for making charcoal, but the bark, which is useful for certain chemical purposes, is exported in large quantities.

Algarrobilla (*Caesalpina Brevifolia*) is a shrub peculiar to the Atacama and Coquimbo districts. It produces an excellent firewood, but is chiefly valuable for the berry which it bears and which is used for tanning leather. With the exception of about 100 tons consumed in the country in the leather industry, the whole production is exported to Europe. The crop varies from year to year, sometimes amounting to 4,000 tons and at other times to only 300. Experiments have been made to transplant this shrub in other countries, and even in other districts of Chile, but so far without success.

* * * *

The Government is beginning to take an interest in the forests, and facilities are afforded to those desiring to plant trees. The various agricultural societies sell annually some million of plants, principally eucalyptus and cypress, with a view to re-wooding grounds which in the past have been sadly neglected. This planting of saplings is not confined to the southern provinces, but is usual throughout the central zone and as far north as Coquimbo.

In general, it may be stated that the forests of Chile form one of its most valuable possessions. Added to this is the fact that private enterprise has been awakened, and plantations of eucalyptus, cypress, and poplars have been springing up throughout the country. Although there are several concerns engaged in the industry, only a very small portion indeed of the tracts of forests have been touched. There are innumerable difficulties

* Published by H.M. Stationery Office. 2*s.* net.

in the way of transportation owing to the lack of roads and rivers capable of rafting the lumber to the coast, but when these matters receive adequate attention from the Government, Chile will take an important place in supplying the lumber requirements of its South American neighbours.

Apart from the general idea of the exploitation of lumber as lumber, the Chilean forests open an important field for the manufacture of wood-pulp.

JADE, AMBER, AND PRECIOUS STONES IN BURMA.

Burma is famous for its jade. The greater part of the jade of fine quality, however, is exported to China, whose fondness for the apple-green tinted jade is well known. It is therefore disappointing to tourists who visit Burma expecting to find plenty of jade of the first quality for sale at a reasonable price to learn that the best is taken by the Chinese market, which will pay even higher than tourist prices. Moreover, writes the United States Consul at Rangoon, the jade carved in Burma is rather crudely done, in comparison with the neat and beautiful work of the Chinese, which has become so popular for jewellery. Burmese settings are always of yellow gold, so that the jade is made almost ugly by both carving and setting.

The production of jade from April 1, 1921, to 31st March, 1922, amounted to 3,816 cwt. valued at 701,673 rupees (about £46,800).

Burma has only a small output of amber and that produced is not considered by experts to be as desirable as Baltic amber, being harder. It is found in clays of probably the Miocene age. There is little variety in the colour, which is bright cherry yellow with a reddish tint that fades into a dirty brown. It is used in the manufacture of rosaries and Burmese ornaments. Little is exported save in the form of beads, which are pretty and effective but not generally popular even in Burma.

No companies are working the jade and amber mines situated in the Hukong Valley. They are in the hands of chiefs of the area and at present are operated entirely by native methods. Jade and amber are also found in the public forest land of Upper Burma particularly in the Myitkyina and Upper Chindwin districts. The right of assessing and collecting royalty on the output of the public forest land is granted by license, at present held by a Chinaman.

Next to petroleum rubies are the most valuable mineral product of Burma. They are found in a variety of places—at Manyaseik, in the Nyitkyina district; in the stone tract of the Sagyin Hills, in the Mandalay district; and in small quantities in a few other places. The only place, however, where the returns are really profitable is the Mogok area, about 90 miles north-east of Mandalay. The ruby tract proper, consisting of mines at work and those abandoned, extends to about 66 square miles. The area in which mines are in active operation covers 45 square miles.

The latest figures available for the production of amber, jadeite, rubies, sapphires, and spinels in Burma are for the year 1921, and are as follows:—

Items.		Amount.	Value.
			Rupees.
Amber	cwt.	26,357	16,843
Jadeite	do	3,816	701,673
Rubies	carats	112,197	691,209
Sapphires	do	48,916	57,232
Spinels	do	32,802	14,027

"KILIM" CARPET INDUSTRY OF POLAND.

The "kilim" is a handmade carpet of wool on a ground or foundation of flax or hemp which, it is claimed, adds very greatly to its durability. The patterns may be generally divided into two categories those with geometrical figures, used for carpets, and those with designs of flowers and animals, for wall decorations. The carpets are made in the usual sizes, and as large as [illegible] by 20 feet. For richness of colour and quality of weaving, reports the United States Consul at Warsaw, the Polish "kilims" of the better grades can be compared favourably with Persian carpets, and also have the advantage of being less expensive.

The present yearly output is approximately 80,000 square metres (1 square metre + 1,195). This amount is produced on approximately 3,000 looms, and fully 75 per cent. of it in homes by weavers who have learned the art from their ancestors. The largest workshop has only 20 to 30 looms.

Prior to the World War the surplus production was marketed in Vienna, but since 1920 small quantities have been exported to England, France, Belgium, Italy and Switzerland. It is claimed that the present production could be increased by 400 or 500 per cent in the course of a year. The producers have no central selling organization but sell their products in small quantities as they are finished. Producing centres are reached easily from Warsaw.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock:—

January 30.—Sir Richard Arthur Surtees Paget, Bt., "The History, Development and Commercial Uses of Fused Silica." Sir Herbert Jackson, K.B.E., F.R.S., will preside.

FEBRUARY 6.—IEMASA TOKUGAWA, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." (With Cinematograph Illustrations.) LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

FEBRUARY 13.—H. MAXWELL-LEFROY, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., will preside.

FEBRUARY 20.—PERCIVAL JAMES BURGESS, M.A., F.S.S., Chairman, Rubber Growers' Association, "New Uses for Rubber."

FEBRUARY 27.—CHARLES S. MYERS, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation."

MARCH 5.—MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman Imperial War Graves Commission, "Building and Decoration of the War Cemeteries."

MARCH 12.—ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.) SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., will preside.

MARCH 19.—R. L. ROBINSON, Member of the Forestry Commission, "The Forests and Timber Supply of North America." LORD LOVAT, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O will preside.

MARCH 26.—NEAL GREEN, "The Fishing Industry and its By-Products."

Dates to be hereafter announced :—

SIR LYNDEN MACASSEY, K.B.E., "London Traffic."

BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "Roads."

FRANK HOPE-JONES, M.I.E.E., Vice-Chairman British Horological Institute, "The Free Pendulum."

J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation."

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock :—

FEBRUARY 15.—SIR RICHARD M. DANE, K.C.I.E., Commissioner, North India Salt Revenue, 1898-1907, and Inspector-General of Excise and Salt for India, 1907-09, "Salt Manufacture in India." THE RT. HON. LORD MESTON, K.C.S.I., LL.D., will preside.

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons at 4.30 o'clock :—

FEBRUARY 5.—F. W. WALKER, "The Commercial Future of the Backward Races, with Special Reference to Papua." SIR GEORGE R. LE HUNTE, G.C.M.G., will preside.

MARCH 4.—THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak." THE RT. HON. LORD BEARSTED will preside.

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

CANTOR LECTURES.

ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." Three Lectures.

SYLLABUS.

LECTURE II: JANUARY 28.—Suspension Colloids. Peptisation, protection and precipitation. Colloidal Mill. Electric cataphoresis and endosmose. Peat drying. Colloidal metals, Colloidal fuel, Ore flotation. Smokes, condensation of fumes, powdered fuels. Mists, Insecticides.

LECTURE III: FEBRUARY 4.—Emulsion Colloids. Preparation and Stabilisation. Coal tar disinfectants, Milks, Phase inversion, biological importance, greases, antigens. Soaps. Ionic micellae.

Adsorbing Gels. Silica gels, ferric oxide and alumina, clays, vaseline, rubber and textiles. Membranes, permeability. Equilibria at membranes, application to leather.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

COBB LECTURES.

Monday evenings, at 8 o'clock:—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 28..Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. S. C. Bullock, "The Tocantins and Araguaya Rivers, Brazil."

Architectural Association, 34, Bedford Square, W.C., 8 p.m. Mr. B. Oliver, "The Case for the Preservation of Old Buildings."

University of London, University College, Gower Street, W.C., 4.15 p.m. Prof. L. M. Brandin, "La Poésie Lyrique Francaise du Moyen Age."

5.15 p.m. Dr. A. S. Parkes, "The Mammalian Sex-Ratio." (Lecture I.).

At the Royal School of Mines, Imperial College, South Kensington, S.W., 5.15 p.m. Prof. H. H. Dixon, "The Transpiration Stream (Botany). (Lecture I.)

At King's College, Strand, W.C., 6 p.m. Mons. R. Nathan, "Le Théâtre d'Idées, Alexandre Dumas Fils." (In French).

5.30 p.m. Dr. O Voladio "Channels of Modern Czech Literature." (Lecture II.).

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C., 5 p.m. Mr. C. H. Maltby, "Some suggested Amendments to the Assurance Companies Act, 1909."

Scottish Society of Arts, 54, George Street, Edinburgh, 8 p.m. Captain P. P. Eckersley, "The Thermionic Valve and its Application to Broadcasting."

[TUES]DAY, JANUARY 29..Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. A. Dendy, "What is Heredity?" (Lecture I.).

Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, Piccadilly, W., 4.30 p.m.

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. J. Williams, "Book Illustration Previous to Photography."

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. H. Campbell, "The Gas Turbine."

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. G. A. Sutherland, "Auditorium Acoustics."

At King's College, Strand, W.C., 5.30 p.m. Sir Bernard Pares, "Russia before Peter the Great to 1861." (Lecture II.).

At the Royal School of Mines, Imperial College, South Kensington, S.W., 5.15 p.m. Prof. G. H. Dixon, "The Transpiration Stream." (Botany). (Lecture II.).

Dyers and Colorists, Society of, Dyers' Hall, Dowgate Hill, E.C., 7 p.m. Dr. A. C. Thaysen, "The Effect of the Action of Micro Organisms on Fibres and Fabrics."

WEDNESDAY, JANUARY 30..United Service Institution, Whitehall, S.W., 3 p.m. Major-General Sir J. H. Davidson, "Imperial Defence."

British Decorators, Institute of, Painters Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. W. H. Cantrill, "A Pilgrimage to the Hill Towns of Umbria."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. B. H. Morgan, "The Work of the Imperial Economic Council."

Literature, Royal Society of, 2. Bloomsbury Square, W.C., 5 p.m.

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. C. Davenport "Illuminated M[anu]scripts."

At King's [Coll]ege, Strand, W[.C.,] 5.30 p.m. Mr. L. F[re]zman, "Mediæ[val] Industries and Socia[l]e."

At the Lo[ndon] School of Econ[omic]s, Houghton Street, [Ald]wych, 5.30 p.m. Dr. A. P. Newton, "[The] Founding of [th]e British Empire."

At the Ro[yal] School of Mi[nes,] Imperial College, Sou[th K]ensington, S.W., 5.15 p.m. Prof. H. H. [D]ixon, "The [Tra]nspiration Stream." (B[ota]ny). (Lecture [II]I.)

Hull Chemical and Engineeri[ng] Society, Photographic [Soc]iety's Rooms, [J]ey Street, Park Street, [Hu]ll, 7.30 p.m. [M]r. C. H. Hardy, "A R[evie]w of the Pres[ent] Position of Liquid Fue[l]."

THURSDAY, JANUARY 31..[Roy]al Institution, Albemarle Street, W., 5. p.m. Mr. [W.] Sickert, "Straws from Cumberland [Ma]rket." (Lecture III.)

Antiquaries, Soci[ety] of, Burling[ton] House, Piccadilly, W., 0 p.m.

Electrical Enginee[rs,] Institution [of,] Victoria Embankment, W., 6 p.m. P[rof]. W. M. Thornton, "Som[e] Researches o[n] the Safe Use of Electricit[y i]n Coal Min[es]."

Royal Society, Bu[rlin]gton House, [P]iccadilly, W., 4.30 p.m.

Auctioneers and Est[ate] Agents, Inst[itu]te of, 34, Russell Square, W.C., 6.30 [p.]m. Mr. H. Beavan, "Va[lua]tions."

Economics and P[olitic]al Science[,] London School of, Hough[to]n Street, [A]ldwych, W.C., 5 p.m. Sir [Hu]bert L. Sm[it]h, "The Economic Laws [of] Art Pro[du]ction." (Lecture III.)

University of Lond[on,] Universit[y] College, Gower Street, W., 5.30 p[.m.] Prof. E. G. Gardner, "[Ju]ano Bocca[lini], Critic and Humorist."

5.15 p.m. Prof. J. G. de Mon[tm]orency, "Comparative Custom[ar]y Law of E[ur]ope and Asia." (Lecture II.)

8 p.m. Prof. H. Butler, "Roman Private Life." (Lect. II.)

At King's College, Str[an]d, W.C., [5.]30 p.m. Prince D. S. Mirsky, "[Th]e History [of] Russian Literature." (Lecture II.)

At the London School o[f M]edicine fo[r] Women, Hunter Street, W.C., [5] p.m. Pr[of.] W. C. Cullis, "Respiratory [E]xchanges." (Lecture II.)

Chemical Industry, So[cie]ty of [(M]idland Sections), University [Bu]ildings, [E]dmund Street, Birmingham, 7. p.m. M[r.] H. T. Tizard, "Some Sp[eci]al Probl[em]s in Volumetric Analysis."

FRIDAY, FEBRUARY 1..Royal Inst[itu]tion, A[l]bemarle Street, W., 9 p.m. [Pr]of Sir William Bragg, "Recent Resea[rch] on Crystalline Structure."

Philological Society, U[niv]ersity College, Gower Street, W.C., 8 p.m. Prof. A. Mawer, "English Place N[am]e Society."

Geologists Association, U[niv]ersity College, Gower Street, W.C., 7.30 [p.]m.

Mechanical Engineers, Instit[ut]ion of, Storey's Gate, Westminster, S.W., [7] p.m. (Informal Meeting). Mr. H. H. [Jo]hnson, "The Possibility of Main Line Ra[ilw]ay Electrification in Great Britain."

(Yorkshire Branch), Philosophical Hall, Park Row, Leeds, 7.30 p.m. [M]r. L. Pendred, "The Production of Technic[al] Newspapers."

Photographic Society, 35, [Ru]ssell Square, W.C., 7 p.m. (Pictorial Gro[up]). Mr. F. C. Tilney, "An Impromptu [N]aturalism in Photography."

University of London, Univ[er]sity College, Gower Street, W.C., 5 p.[m]. Prof. J. Robertson, "The Influence of T[o]wn Planning and Housing in Public Health." (Lecture II).

5.15 p.m. Mr. H. Higgs, "P[ro]tection and Free Trade."

At King's College, Strand, W.C., 5 p.m. Dr. W. D. Lang, "Some Pa[læ]ontological Evidence with regard to E[v]olution." (Lecture I.)

5.30 p.m. Prof. R. W. Se[ato]n-Watson, "The Rise of Nationality in the Balkans." (Lecture II.)

SATURDAY, FEBRUARY 2..Royal Institution, Albemarle Street, W., 3 p.m. Mr. W. Wallace, "Influence upon Composition of Improvements in Musical Instruments."

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FRIDAY, FEBRUARY 1, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2).

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 4th, at 8 p.m. (Cantor Lecture). ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." (Lecture III.)

TUESDAY, FEBRUARY 5th, at 4.30 p.m. (Dominions and Colonies Section). F. W. WALKER, "The Commercial Future of the Backward Races, with Special Reference to Papua." SIR GEORGE R. LE HUNTE, G.C.M.G., will preside.

WEDNESDAY, FEBRUARY 6th, at 8 p.m. (Ordinary Meeting). IYEMASA TOKUGAWA, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." (The paper will be illustrated with cinematograph views.) LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

SEVENTH ORDINARY MEETING.

WEDNESDAY, JANUARY 23rd, 1924; MR. GEORGE E. BROWN, F.I.C., Editor of the *British Journal of Photography*, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Bailey, Charles Henry, Chepstow, Mon.
Chamberlain, Clark W., A.B., Ph.D., Granville, Ohio, U.S.A.
Charawanamuttu, V. Edward, A.C.P., Kotahena, Colombo, Ceylon.
Cutner, Mrs. Frances Maud Mayfield, London.
Davis, Cecil, London.
Edwards, Kenneth C., Chester.
Evans, Samuel, Johannesburg, S. Africa.
Fuge, Captain William Valentine Greatraks, Cairo, Egypt.
Graham, Archibald, Oxford.
Gray, Arthur Wellington, Ph.D., Delaware, U.S.A.
Gray, Major-General William du Gard, C.B., J.P., Dulverton, Somerset.
Hooker, Dr. Samuel Cox, Brooklyn, New York, U.S.A.
Jones, Arthur Cadbury, London.
Khadir Meera Sahib, S.K.I., Salem, India.
Kimbell, Alfred Edward, London.
Klein, Millard A., Ph.D., Stockton, California, U.S.A.
McGregor, Dr. Robert, Michigan, U.S.A.
McLaughlin, Professor George D., Cincinnati, Ohio, U.S.A.
Matthews, William Cooper, Stafford.
Morley, Henry Thomas, Reading.
Morrison, Francis, B.Sc., London.
Morse, Charles, K.C., D.C.L., Ottawa, Canada.
Plummer, Professor Henry Stanley, M.D., Minnesota, U.S.A.
Pullen, Hugh C. G., Rio de Janeiro, S. America.
Ramsay, Dr. William Miller, Nausori, Fiji.
Rose, Joseph William, Bath.
Rose, Mrs. Ruth Starr, Maryland, U.S.A.
Rosenberg, Charles Conrad Constantine, M.D., Oregon, U.S.A.
Sahni, D. C., M.A., Patiala, India.
Spencer, Walter T., London.
Tatham, Francis John, London.
Townson, Rev. C. H., M.A., Warminster.
Ward, Sir Thomas Robert John, C.I.E., M.V.O., London.

The following candidates were duly elected Fellows of the Society:—

Clark, John Murray, LL.D., K.C., Toronto, Ontario, Canada.
Cullen, Jos. F., Salt Lake City, Utah, U.S.A.
Goode, Clarence S., M.Inst.R.E., Hinckley.
Hibberd, Reginald James, M.Inst.R.E., Haslemere, Surrey.
Keith, Charles, Kansas City, U.S.A.
Ledigard, Edgar M., Salt Lake City, Utah, U.S.A.
Life, Professor Frank M., Tucson, Arizona, U.S.A.
Manekshaw, F. H., London.
Mitra, S. B., London.
Rayakar, B. V., Bombay, India.
Sethna, F. M., Bombay, India.

A paper on "Cinematography in Natural Colours—further Developments," was read by MR. G. ALBERT SMITH.

The paper, which was fully illustrated with scenes from H.R.H. The Prince of Wales's Tour in India, will be published in a subsequent number of the *Journal*.

CANTOR LECTURE.

On MONDAY, JANUARY 28th, 1924, DR. ERIC K. RIDEAL, M.B.E., B.A., D.Sc.,

F.I.C., of the Chemical Laboratory, The University, Cambridge, delivered the second lecture of his course on "Colloid Chemistry."

The lectures will be published in the *Journal* during the summer recess.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Precise Length Measurements," by Mr. J. E. Sears, Jun., C.B.E., M.A., M.I.Mech.E., A.M.Inst.C.E. have been reprinted from the *Journal* and the pamphlet (price 4*s.*) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.2.

A full list of the lectures, which have been reprinted and are still on sale, can also be obtained on application.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post free, for 2*s.* each, on application to the Secretary.

SCHEME FOR THE IMPROVEMENT OF INDUSTRIAL DESIGNS.

A short article describing the Scheme for the Improvement of Industrial Designs, which the Society is inaugurating, appeared in the *Journal* of October 26th, 1923. This outlined the objects of the Scheme, and gave the names of those serving on the various Committees, and the first list of subscriptions to the fund for providing scholarships and prizes. Since that date the following additional subscriptions have been received :—

SECOND LIST OF SUBSCRIPTIONS TO THE FUND FOR PROVIDING PRIZES AND SCHOLARSHIPS.

Amount previously acknowledged	£589	5	0
The Federation of Calico Printers	50	0	0
Messrs. Lever Bros., Ltd.,	50	0	0
The British Flint Glass Manufacturers' Association	30	0	0
Messrs. G. P. & J. Baker, Ltd.	20	0	0
Messrs. Brintons, Ltd.	10	10	0
Carpet Trades, Ltd.	10	10	0
Messrs. John Dickinson & Co., Ltd.	10	10	0
The Haberdashers' Company	10	10	0
Messrs. Hampton & Sons, Ltd.	10	10	0
The Weavers' Company	10	10	0
E. Kahn, Esq.	10	0	0
Messrs. Riddick, Stuttart, Ltd.	10	0	0
George Barber, Esq.	5	5	0
Mrs. E. Graydon-Bradley	5	5	0
Messrs. Heal & Son, Ltd.	5	5	0
William Jardine, Esq.	5	5	0
Messrs. Keeble (1914), Ltd.	5	5	0
London Cabinet and Upholstering Trades Federation	5	5	0
Messrs. Mander Bros.	5	5	0
The Medici Society, Ltd.	5	5	0
Thomas Muddiman, Esq.	5	5	0
Messrs. Neckwear, Ltd.	5	5	0
Federation of Lace and Embroidery Employers Associations	5	5	0
Federation of Master Printers and Allied Trades	5	5	0
Messrs. Shuffrey & Co.	5	5	0
Paul Waterhouse, Esq., F.S.A., F.R.I.B.A.	5	5	0
Messrs. Crofts & Assinder, Ltd.	5	0	0
Edgar Greenwood, Esq.	5	0	0
Sir Ernest Hodder-Williams, C.V.O.	5	0	0
Messrs. A. B. Jones & Sons	5	0	0
Messrs. R. H. & S. L. Plant, Ltd.	5	0	0
Percy Scott Worthington, Esq., M.A., F.R.I.B.A.	5	0	0
Messrs. J. Aynsley & Sons	2	2	0
S. D. Bianco, Esq.	2	2	0
Messrs. A. Cooper & Co.	2	2	0
Messrs. H. S. Fraser, Ltd.	2	2	0
Messrs. W. Skull & Son, Ltd.	2	2	0
E. R. Edis, Esq.	1	6	6
A. Barone, Esq.	1	1	0
C. H. Bowers, Esq.	1	1	0
The City Cabinet Company	1	1	0
H. J. Colclough, Esq.	1	1	0
Messrs. S. Epstein, Ltd.	1	1	0
Godfrey Giles, Esq.	1	1	0
S. D. Kitson, Esq. F.R.I.B.A.	1	1	0
Professor Beresford Pite, F.R.I.B.A.	1	1	0
G. Gilbert Scott, Esq., R.A.	1	1	0
E. Gomme, Esq.		10	6
H. R. Linton, Esq.		10	6
Messrs. Lotinga Bros.		10	6
Messrs. D. Buckle & Son		10	0
C. Van Doorsselaer, Esq.		5	0
	£949	7	0

The first Annual Competition of Industrial Designs will be held in June next at the Victoria and Albert Museum, and particulars can be obtained on application to the Secretary of the Royal Society of Arts. Over £1,000 will be offered in Travelling Scholarships and Money Prizes in the various sections, and the Society's Diploma will be conferred on any candidate whose work reaches a very high standard of artistic ability and also shows practical knowledge of the materials and processes of his trade.

A number of selected designs will be exhibited at the Victoria and Albert Museums, and subsequently at suitable centres in the provinces. In this way they will be brought immediately to the notice of those manufacturers who are likely to be specially interested in them.

The Council hope to place the Scheme on a permanent basis and to offer annually travelling scholarships and prizes. In order to secure this object a very substantial capital sum will be required. They therefore appeal to all those who not only are interested in the artistic industries of the country, but are concerned for the general improvement of British trade to assist them in promoting the Scheme. Contributions to the Fund should be addressed to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.2.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

Friday, January 4th, 1924.

General Sir Edmund Barrow, G.C.B., G.C.S.I., Member of the Council of India, in the Chair.

The Chairman said he had only one qualification for presiding on such an occasion. It would be remembered that Mr. Birrell frequently prided himself on the fact that he was born in a library. He (the Chairman) could boast that he had been born in an Indian arsenal, and, therefore, had some connexion with the Ordnance Department. His father, an Artillery officer, at the time he (the Chairman) was born was in charge of the Secunderabad Ordnance Depot.

The lecturer, General Young, had had over 30 years' experience of the Indian Ordnance Department, having served in most of the Indian factories. In 1914, just after the War commenced, he became Deputy-Director of Ordnance in India, and in 1917 Director of Ordnance. He thus spoke with considerable knowledge both of the Indian Ordnance in pre-war days and of the Indian Ordnance during the Great War. For his work as Deputy-Director General Young gained the Companionship of the Order of the Indian Empire, and later obtained the C.B.E.

The paper read was :—

THE INDIAN ORDNANCE FACTORIES AND INDIAN INDUSTRIES.

By Brigadier-General H. A. Young, C.I.E., C.B.E., (R.A., retired).

Director of Ordnance Factories, India, from 1917 to 1921.

The production and supply of military equipment is a by-way of history but little explored by the historian. The earliest armies obtained their weapons from the nearest forest or beach and nobody thought it necessary to describe the forest or the beach, and the fashion thus set has been followed down to quite recent times. The last great war has made us realise, however, that, while an army may march on its stomach, a nation fights with its factories. Before the invention of gunpowder the fighting man, if he could not equip himself, was able to obtain his needs from local craftsmen. The provision of firearms and powder required special industries which could be carried on only by numbers of workers acting together in organised workshops. Originally these workshops were privately owned and in England it was not till 1716 that the manufacture of cannon was established in a Royal Foundry at Woolwich, and not till 1787, when mills at Waltham were purchased, that gunpowder was produced in quantity in a State owned factory.

The Ordnance Factories in India have a long and interesting history, distinctly creditable to the officers who have managed them; but this history has never been written and less is known to-day of the sources of supply of Indian Army equipment than was known in the first half of last century, when the officers of the Arsenals and Factories came from the Presidency Artilleries and returned to regimental duty for service and on promotion to Lieutenant-Colonel. Rare indeed, in my experience, have been visits from officers unconnected with the Department to any Ordnance establishment. A Commander-in-Chief was once allowed half an hour for a visit to the Cordite Factory and was amazed to find that he could not enter any building nor view manufacture in the allotted time.

The East India Company in its early days was interested in military equipment mainly as saleable goods. Despatches of muskets, shot, powder and guns for sale are recorded from 1600 onwards. In 1658, 15 iron guns, 2 mortars and 800 shell were consigned to Madras to be sold "to our most profitt," it being believed that the wars in India would cause a great demand for such things.

In 1626 the Company attempted to establish powder works in England and set up mills near Windsor; but the King ordered their removal, as they disturbed the royal deer. Mills were then rented at Chilworth; but Evelyn, who had the monopoly of powder making, obtained an interdict. When this was removed, the Company's Powder Maker, a survivor of the Amboyna Massacre, died, and finally there was trouble over the rent,

so in 1636 they assigned the lease and abandoned the idea of making powder in England. This decision must also have been due to a realisation of the possibilities of manufacture in India, where all materials were easily obtainable. Though neither gunpowder nor firearms were invented in India, and their first recorded use was at the Battle of Panipat in 1526, their manufacture had been quickly established in many of the Indian kingdoms.

The first manufactories established by the Company in India were Powder Mills, though the exact date is uncertain. In 1660 a ship was sent from Surat to Calicut to "obtain a supply of gunpowder, which was very dear at Surat, as there was only one maker there." In 1670, however, the Council ordered the Factors at Karwar to buy saltpetre for powder manufacture at Bombay, and seven years later recommended a Surat powder maker who was prepared to make powder at Bombay at a specially cheap rate. Bombay seems to have accepted the offer and a powder mill was built not far from the Castle. Madras must have had a powder mill in 1672, as in that year the Chief at Masulipatam was ordered to send teak timber to Madras for the Powder Mills, which were located in old Black Town.

These early gunpowder factories were not substantially built works making powder of any quality; even up to the end of the 18th century powder was made by the most primitive methods, in the cheapest structures and with little regard to the danger of the operations. In the first powder works at Bombay the ingredients were beaten in wood mortars by women and boys, who were pressed for the work, and even in 1794 powder was made by the Agent in Bengal by foot mills in mat huts and sifted in leather sieves. Explosions were frequent, often causing great loss of life, for, in addition to the risks attendant on the use of primitive appliances, there was often extraordinary carelessness. For example, at Bombay in 1677, some 35 barrels of powder were spread out to dry on a bastion, when a corporal filled an old bandolier with wildfire, intending to tie it to a dog's tail, but not finding the dog, threw the bandolier towards one of the houses. The wind being very strong the bandolier blew on the bastion, fired the powder, which killed a sentry and 8 coolies, blew open magazine and other doors, shook the town and damaged the bastion. They held a Council of War on the corporal, cashiered him and made him run the gauntlet three times as an example to all. The location of the mills was constantly changed as explosion destroyed them or they became surrounded by houses. At Madras after the first one there were three in succession on different parts of the Island, one of which was destroyed by the French in 1746. Then powder came from Fort St. David till, in 1753, mills were erected in the Egmore Redoubt, materials from a church in Fort St. George being utilised. Six years later the French destroyed these works and temporary sheds were used till they blew up, killing many people. The next site was in new Black Town, on the ground now occupied by the Government Press, and when these mills were ruined by explosion, works were established in 1802 at Perambur, which continued till powder manufacture ceased in 1887. At Bombay the second site was on Old Woman's Island, now called Colaba, as in 1731 the original works were pronounced crazy and dangerous. Forty pestles worked by buffaloes were provided; but if buffaloes proved unsatisfactory, a windmill was to be erected. These works were soon abandoned as they were out of the way for the workers, there was no fresh water and no store houses, and other mills were set up on a site near the first. The powder made was said to be superior to Europe powder, though the Court thought it should have been cheaper, but at this time English powder was most indifferent and Fortescue states that as late as 1779 Admiral Barrington was complaining bitterly about its quality. These works having extended too near the Fort they were removed to Mazagon in 1768, where they remained till 1864. The final move was to Kirkee, where modern works were completed in 1870, and continued working till 1899. This move was a profitable one, as the site fetched 40 lakhs while the new works cost only 16½ lakhs.

It does not appear that Bengal possessed any Government Powder works before 1756, though it is stated that prior to this year Government had spent much money on manufacturing powder near Baugh Bazaar, but with little success. In 1754 proposals for "contracting with the Company for gunpowder" were accepted from Lieutenant-Colonel Scott, who was Engineer General of all the Company's settlements

in the East Indies. He built a powder mill at Perrin's Garden in Baugh Bazaar and on his death, in May, 1754, it was taken over by Captain John Buchanan, who had married a lady said to have been Scott's niece. Buchanan died in the Black Hole and his widow became the first wife of Warren Hastings. Before the siege of Calcutta, however, the powder works had been purchased for the Company for Rs.4,000, Buchanan to receive a gratuity for managing them, and the Council reporting to the Court that they had taken the provision of gunpowder into their own hands. The Court, in approving this action, referred to the importance of the matter and left to the Council to have it made of the best quality and in cheapest manner by contract or otherwise. The Court were never slow in urging economy and in 1759 they informed Bengal that, to save needless expense in powder, they had made new regulations permitting in certain cases ships to salute by cheering. Baugh Bazaar was obviously unsuitable for powder works and for a short time the works were at Akra, between Budge Budge and Kidderpore and Warren Hastings had a farewell dinner with a number of friends at these works on the day he left Calcutta in 1785.

The establishment of powder manufacture in Bengal on a proper scale was due to a remarkable man. Mr. John Farquhar went out to Bombay as a cadet; but having become unfit for active service owing to wounds, he went to Bengal as a free merchant and took up chemistry as a hobby. Lord Cornwallis employed him to investigate the powder works, then made him superintendent and finally sole contractor. The location of the works down the river was considered dangerous by the military authorities and at Farquhar's suggestion the old Ostend Company's settlement at Bankee Bazaar was acquired and he was authorised to erect new works there. These works at Ishapore, as the place came to be called, were completed about 1790 and worked till 1903. Farquhar was unique among Ordnance Factory Superintendents, for he took home with him, when he retired in 1814, half a million pounds and walked from Tilbury to Leadenhall Street to save cab fare.

For close on 30 years Bengal had powder works also at Poppa Mhow near Allahabad, where for a time war rockets were made. It was closed in 1829 by Lord William Bentinck as one of his economies. The three powder works at Kirkee, Ishapore and Perambur are now represented by the Cordite Factory at Auruvankadu, which commenced manufacture in 1904, and the various dangerous operations there have been conducted with extraordinary freedom from serious accidents.

India has always been dependent to a large extent on England for ordnance. Gun making was attempted at Madras in 1709, when a German was entertained in the Gunner's crew as he was said "to perfectly well understand casting of guns and mortars of any size as also how to play 'em." Less than three years later he was pronounced "a person of no judgment," as guns he made split when proved, and he was ordered to be discharged or reduced to gunner's mate. In 1771 a brass foundry was added to the Arsenal of Fort William and ten years later it cast two 12prs. and ten 6prs. for the ship Betsey, going to China with opium. This foundry became a separate charge in 1822, and in spite of the desire of the Court to abolish it, it continued till 1830, when it was removed to Cossipore and re-equipped. From that year it grew till in 1914 it had spread into two great factories, one at Cossipore and one at Ishapore, making not only modern guns and howitzers but projectiles, fuzes, cartridge cases and many other military stores.

It is curious that the Company did not establish gun manufacture earlier and on a more adequate scale, as the manufacture of brass ordnance, even of large calibre, was well established in many parts of India. A gun 4ft. 8 ins. diameter at the muzzle with a bore of 2ft. 4ins. was cast in Ahmednagar as early as 1549. One Richard Bell tells a quaint story of casting guns for Aurangzeb, the guns taking 160 lbs. of powder and a shell of 450 lbs. When he proved the guns he used an elephant as a target, with fatal results to the elephant and much annoyance to the Emperor. There is a letter from the Court dated in 1763 which may explain their neglect of gun making. It says:—"Your indent for brass and iron guns and ordnance stores is so great that it is a further confirmation of our before-mentioned remarks of last season upon the inattention in framing your indents. We cannot therefore by no means think of complying with it fully, more especially when we consider what large quantities

have been taken from the French in the different parts of India." In those simple days a successful army could re-equip itself from the enemy, and some enemies in India were far better equipped than the British. In Seringapatam, when we took it in 1799, there were 444 brass and 478 iron pieces of ordnance, most of the brass and a few of the iron having been cast in Tippoo's own foundry. The fortress had 11 large powder magazines, containing over half a million pounds of powder, 11 armouries with workshops, 2 foundries, 3 gun workshops and 4 great arsenals.

Muskets and rifles have always been imported; but in 1905 a rifle factory was established at Ishapore on part of the site of the old powder works. It had many difficulties to overcome, especially in the training of workmen in the extremely accurate work required in the modern rifle, and it had not reached full production when the Great War broke out.

Ordnance vehicles were made in the country from the earliest times, but no factories under Government control were established till the beginning of the 19th century. Formerly, supplies came mainly from contractors, most of the iron work being imported; and one of the reasons for the defenceless state of Calcutta in 1756 was the lack of carriages for 50 guns newly received from home, the iron work not having arrived though demanded in 1754. A writer, referring to the latter part of the 18th century, says:—"Carriages, ammunition and stores generally were of exceedingly inferior quality, supplied by contractors, who having interest to obtain the contracts, had also sufficient influence to force their wretched produce into the service and to cover themselves from loss or exposure by getting all power of choice or rejection taken from the hands of the Artillery officers." When the Board of Ordnance was instituted in 1775, it placed the arrangements for equipment in the hands of the Commissary General and the Military Storekeeper, who were either themselves contractors or were connected with the contractors. William Hickey in his memoirs says that the position of Military Storekeeper was, in 1783, the most lucrative one in the Company's service. He mentions a Chief Engineer who left over half a million pounds and another gentleman who made £60,000 from a contract at Madras for some batteries.

Gun carriage manufactories were established at Calcutta in 1800, at Seringapatam in 1802 and at Bombay in 1810. The Bengal factory was first at Kidderpore, then both there and at Cossipore. In 1814 another factory was established at Allahabad but was moved to Fatehgarh two years later, and in 1829 the Calcutta factory was also moved to Fatehgarh, which became the sole gun carriage manufactory for the Bengal Army. Even at the time of the Sepoy Mutiny neither this factory nor the fort within which it was situated can have been very impressive. The fort was very dilapidated and the factory was thus described by a writer in 1857:—"The Agency yard is merely an enclosure surrounded by mud walls on three sides, abutting on the river on the fourth. Within these walls is a bungalow for the Agent and large godowns for the reception of muster guns, carriages, ammunition, etc." When the rebels besieged the fort there was no armament other than the muster or pattern guns and the scanty ammunition was supplemented by hammer heads, bolts and nuts. The factory was little injured by the rebels, who attempted to utilise its resources but with small success.

The establishment of a gun carriage factory for the Madras Army was due to the failure of carriages from contract during the operations in Hyderabad, while its location at Seringapatam was the result of the recommendation of Sir Arthur Wellesley. The first Agent was Captain Scott, of the Madras Artillery, who had been called to Seringapatam as Commissary of Stores by Wellesley, owing to serious scandals in the store department. Wellesley wrote in 1801:—"You cannot conceive what a scene of villany has come out." The advantages of Seringapatam did not last, and in 1831 the factory was located in Madras in the Collector's Cutchery, which was formerly the Naval Hospital.

The Bombay factory was located first near the Bazaar Gate, on the site now occupied by St. George's Hospital; but in 1819 the Court approved of its removal to the barracks, lately occupied by the artillery, on Old Woman's Island. In 1841 the Cooperage work of the Military and Marine Departments was transferred to the factory from the Commissariat, and the monopoly of the native contractors was broken down. In 1868 the manufacture of wheels, which was unsatisfactory in the damp climate of Bombay, was transferred to the Poona

Arsenal, and five years later all wood work was concentrated in a branch of the factory at Poona.

Many proposals were made from time to time for the removal of the gun carriage factories to more suitable sites and for their concentration. As far back as 1864 the unsuitability of Bombay was urged, and in 1875 a special Ordnance Commission recommended two factories at Allahabad and Madras. It was not till 1901, however, that Government decided to concentrate all ordnance vehicle work at a central factory at Jubbulpore, and work commenced there in 1904, the existing ones being gradually closed down.

The history of the manufacture of harness, saddlery and accoutrements is somewhat obscure. At first all supplies were imported; but gradually local provision by contract grew up, though importation and to some extent manufacture in Arsenal workshops supplemented this. In 1771 the stock of the Grand Arsenal at Patna included 1,206 country-made sword belts against 2,206 from England. Tanneries owned or managed by Europeans existed in the 18th century, while Commissariat tanneries were fairly common early in the 19th. Madras stated in 1832 that boots and leather appointments were being made of superior quality and at reduced rates at the Commissariat tannery at Hunsur and in 1840 reported that buff leather for accoutrements was also being made there, though only half the annual requirements could be supplied. There is little doubt, however, that the supply of leather was not satisfactory. Bombay informed the Court in 1843 that harness and saddlery supplied by contract was very inferior though no worse than that made in Bengal or Madras, and that Europe harness was much more efficient and economical. A writer in 1848 in an article on the Bengal Artillery stated that "the worst part of the equipment is harness and saddlery, in which considerable improvement is required which can never be obtained till all is supplied from England. Country harness costs nearly as much, lasts half as long and is in every respect inferior. It is understood that the only reason is that the Court desire to improve and encourage Indian manufactures." The truth is that indigenous methods of tanning could not, and do not now, produce good leather.

The history of the Government Harness and Saddlery Factory commences in 1860, when Lieutenant John Stewart, of the Bengal Artillery, was a Deputy Commissary of Ordnance at Cawnpore, and recognised the importance of the place as a centre for leather work, as well as the urgent necessity for improvement in methods. At his suggestion an experimental harness depot was started and the system of tanning in pits adopted in place of the native method of tanning in bags. Tanning was done by contractors, but as they failed to make proper pits or to do the work thoroughly, two experts were obtained from home and manufacture commenced in the depot in 1862. It was not till 1873, however, that the factory really became self-contained and able to turn out complete articles of equipment from the raw materials and in that year it obtained a medal and diploma at the Vienna Exhibition. Stewart remained in charge till 1888, a record for service in one appointment, and his memory is perpetuated by a mounted figure on a temple outside the factory walls. This factory has not always been the sole source of supply, as for many years leather articles were made up in the Bombay Arsenal from leather obtained by contract. The Commission of 1875 recommended that the Cawnpore factory should be extended to meet all requirements; but from 1897 to 1909 harness and saddlery workshops were established in the old powder works at Perambur, leather being obtained from Bombay by contract. The existence of the Cawnpore factory has been threatened more than once, it being thought that the private leather working factories rendered unnecessary any Government establishment. It was most fortunate that the idea had not borne fruit when the War came, as the European managed private factories had more than they could do to cope with the demand for boots, while the ordinary Indian tannery could not produce good leather. The products of this factory are equal in every respect, except possibly appearance, to those produced in Europe.

The history of the ammunition factories is a short one, though the manufacture of ammunition dates from 1748, when the Court sanctioned the raising of a regular company of artillery in each Presidency and sent out a Captain-Lieutenant for each company as Director of the Laboratory. The Court directed that this officer was to have charge of all necessary stores and was "to make and to instruct in making all

military fireworks." The laboratory thus established was the original ammunition factory. The Court desired this institution to be a mystery, as they ordered that "no Indian, black or person of mixed breed, nor any Roman Catholic of what nation soever, shall, on any pretence, be admitted to set foot in the laboratory, or any of the military magazines, either out of curiosity or to be employed in them, or to come near them, so as to see what is doing or contained therein." It soon became impossible to depend on the Company laboratories and in 1790 Commissaries and Deputy Commissaries of Ordnance were directed to perform the business of making up ammunition and all laboratory work under the direction of the Commanding Officers of Artillery.

The change from Arsenal Laboratory to Ammunition Factory was a gradual one and commenced with the establishment of percussion cap factories. One started in the Mazagon Powder Works in 1844 and another at Dum Dum about the same time. Bullets for the Minie rifle were also made in small factories, one being at St. Thomas's Mount from 1858 and another at Bombay, in the Gun Carriage factory, which included also plant for cutting fuzes and tubes. The Cossipore factory also made bullets. The ammunition factory at Dum Dum really dates from 1858, when Captain Symo, of the Bengal Artillery, was placed in charge of the Enfield Cartridge and Percussion Cap Factory; but it was not till 10 years later that the Secretary of State sanctioned the establishment for the new Small Arms Ammunition Factories. The two factories at Dum Dum and Kirkee, the latter completed in 1872, became eventually gun as well as small arm ammunition factories, and in 1901 buildings for the lyddite filling of shell were added to the Kirkee establishment. Unfortunately these factories were still making Mark VI rifle ammunition at the opening of the War, and it was not till some years later that sanction was given to the few alterations necessary to enable the latest pattern to be made. This matter of ammunition had grave results in Mesopotamia, where British-equipped divisions were fighting side by side with those from India, having different ammunition, different methods of carrying ammunition and rifles sighted differently. It is to be hoped that the lesson has been well learnt and that never again will vital military equipment vary in different parts of the Empire.

Now, a few words regarding the personnel. Up to the close of the 18th century equipment was mainly supplied by contract. Though works were the property of Government as in the case of the powder mills, though workshops were provided as in the case of carriage manufacture, the person who supervised the work was remunerated from the price fixed for the article. When powder was made by Colonel Scott or by Captain Buchanan, both officers drawing pay from the Company, the profits of manufacture went to them. Mr. John Farquhar, when he was superintendent at Ishapore, received Rs. 5 for each barrel made, and when he became contractor he was given Rs. 32 per barrel. Dr. Helenus Scott, of the Bombay Medical Service, who was agent for gunpowder in Bombay from 1796, was paid for the powder produced and had also the contract for spirits. It was not till 1813 that the Court decided that superintendents of factories should be army officers, preference being given to the Artillery. A few years later it was ordered that no officer in such an appointment was to derive any profit from it other than the authorised pay and allowances, which, I may mention, were higher than in recent times. These appointments were bestowed on fairly senior officers as a rule, with claims to reward, either from distinguished service or sometimes from relationship with high authority. Many distinguished officers appear in the lists, including Augustus Abbott, who commanded the artillery of the 'illustrious garrison' of Jellalabad, Vincent Eyre, who relieved Arrah, Archdale Wilson, who commanded at the siege of Delhi. Many officers were thanked and rewarded for their services in improving or cheapening manufacture, though there were cases when the Court were moved to ask what enquiry had been made into the qualifications of the officer before appointment.

It is obvious that any officer, whose experience has been purely military, must have much to learn when appointed direct to the charge of a manufacturing establishment. Yet it was not till nearly the end of the 19th century that a Director General of Ordnance was found far-sighted and strong enough to insist that there must be a graded service in which officers would have to qualify themselves for positions of responsibility. To the late Major-General Alexander Walker must be given the chief credit for the efficiency of the Ordnance

Department during the past 30 years. Unfortunately the principles which General Walker followed have since been departed from, and this is perhaps one reason why it is now difficult to obtain officers for the factories.

It has been urged that the Artillery officer is not the best possible factory superintendent and that the present large manufacturing establishments would be more efficient if placed under civilian engineers. A good deal can be said on both sides, and, no doubt, the best engineer would be better than even the picked artillery officer; but no salary likely to be offered by India would attract the best civilians. Many manufacturing companies in this country are controlled by men who have no engineering qualifications, and it is not always best to have purely technical knowledge at the top. The Ordnance Factory Superintendent needs most knowledge of Army requirements and a gift for management. The present eight great Ordnance Factories in India are no unworthy monument to the devoted labours, extending over a century, of the Artillery officer. It is essential, however, if the best type of officer is to be obtained, that the pay be increased and prospects of advancement assured. It would be of advantage to the home ordnance factories as well as to the Indian factories, if there was an interchange of officers and, if possible, of technical foremen also. While the home staff is far more modern in its ideas and methods and is in close touch with industrial progress, it lacks intimate knowledge of the severity of service imposed by climate and other conditions abroad on military equipment.

From quite early days technical men were obtained from England as foremen. In 1753 the Court sent to Bombay a man skilled in burning charcoal to serve on the powder works at £60 a year. When the Gun Carriage Agency was established in Bombay the Court were asked to send out 3 foremen—carpenter, blacksmith and wheelwright. In 1813 a Mr. John Braddock, son of the Master Refiner at Waltham Abbey, was sent to Madras, "to practise and teach the art of making gunpowder." Early in the century the Madras Powder Works had a Frenchman as foundry foreman and he was sent to Calcutta to assist in the casting of cylinders for the Ishapore Works. Supervision was, however, mainly in the hands of Europeans drawn from the Army and employed as overseers, being either warrant officers of the Ordnance Department or soldier mechanics. At the Gun Carriage Factory, Fatehgarh, in 1895, there were 2 civilian foremen, 5 or 6 soldier mechanics and 8 or 9 warrant officers; there were no Indians above the grade of mistry, nor were there any qualified by education or training for any higher post. There was in 1864 a Parsee Head Powder Maker at Bombay on Rs. 280 per month, but he was exceptional, as he had been to England and had acquired knowledge of Waltham Abbey methods.

There has been little attempt to train the Indian for posts of responsibility in the Ordnance factories. There were more schools attached to the factories in the middle of last century than were in existence at its end; but these schools did not pretend to fit lads for supervisory posts. There was a very sound institution started at Madras in 1818; this was the Corps of Carnatic Ordnance Artificers, in which young Eurasians were educated, taught trades and given a chance of rising to positions of minor responsibility. The Corps was allowed to die out, unfortunately, and had practically disappeared by the end of the century. Technical supervision is now carried on almost entirely by civilians recruited from England, warrant and non-commissioned officers of the Ordnance Department being employed for store duties.

In 1885 there were 10 Ordnance Factories, 3 Gunpowder at Madras, Kirkee and Ishapore; 3 Gun Carriage at Madras, Bombay with branch at Poona, and Fatehgarh; 2 Ammunition at Kirkee and Dum Dum; 1 Gun and Shell at Cossipore; 1 Harness and Saddlery at Cawnpore. In 1914 there were 7 only:—1 Cordite at Auruvankadu; 1 Gun Carriage at Jubbulpore; 2 Ammunition at Kirkee and Dum Dum; 1 Gun and Shell at Cossipore with branch at Ishapore, now a separate factory known as the Steel and Metal Factory; 1 Harness and Saddlery at Cawnpore; 1 Rifle at Ishapore. In 1914 these factories employed about 13,000 men and the value of a year's output was approximately 240 lakhs of rupees. At the Armistice the workers numbered close on 39,000, and the value of out-turn was over 880 lakhs. Speaking generally they made complete, from raw materials, field and mountain guns and howitzers, with their carriages and other vehicles, and most of their equipment. Gun and small arm ammunition, rifles, bayonets, transport vehicles, harness,

saddlery and accoutrements were also completely made. In addition steel and other metals were melted and rolled for various purposes and the cordite factory made gun-cotton for the Engineer services.

The factories were not prepared for a World War. They were supposed to be capable of maintaining supplies for any frontier war; but Lord Kitchener's plans had not been fully carried out and the manufacturing capacity required to maintain the largest army which India could place in the field had not been worked out. No plans existed for the expansion of the factories and their maximum capacity was not known. India, moreover, had ceased to be in the forefront of military progress and much of its equipment was of patterns discarded by the home army, with the result that the plant of its factories was not adapted for the manufacture of many articles of modern equipment.

For some time the factories worked only the normal 48 hours per week and no adequate steps were taken to expand either in personnel or in plant. Sanction was eventually obtained to the employment of tradesmen from territorial units and later of men from civil life; but the latter were few and the former new to Indian conditions and were rarely technical experts. Even then proper night shifts were impossible, as many factories had no adequate lighting and there was a scarcity of workmen. Unfortunately, civilian industry was not controlled, and continued to use material and labour on work of no military value.

Demands for many new stores poured in from the forces overseas, and it then became apparent how dependent on other countries India was for much of the material used in the manufacture of military equipment. Much of the raw material was in India, but it had either not been exploited or required treatment which could not be given in the country. Moreover, special plant and skilled supervision was often needed which were not available. India could not make, for example, machine guns, bombs, grenades, pistols, trench mortars, high explosives nor the detonating fuze. Acetone, glycerine, sulphur and sodium nitrate all required for explosive manufacture, were imported. India did not even manufacture sufficient leather of good quality and supplies had to be obtained from Australia, though all the necessary materials for leather manufacture are among India's chief exports.

India can point with justifiable pride to what it did in the Great War, but it is possible that future historians may comment on what it might have done had a longer and a wider view been taken and its great resources been exploited from the very beginning. The factories which should have devoted the whole of their none too plentiful labour, material and plant to the production of stores for the forces overseas, were making cartridges for saluting and time guns, special equipment for body-guards and maintaining a host of obsolete guns and other equipment, while a fear of local trouble locked up much valuable material and stock. Some years of war passed before India had shaken off some of its normal administrative inertia.

In 1917 the home authorities sent out a commission, headed by Sir Frederick Black, to consider what could be done to obtain a far larger output of gun ammunition. As a result it was decided to erect new shops complete with plant to produce about three times the existing output, the ammunition to be of the latest patterns. A considerable staff was sent out and buildings erected at Cossipore, Ishapore, Dum Dum and Kirkee; but it was obvious that the difficulties had been underestimated and that the scheme as worked out in England was on too huge a scale for completion within the time allowed. The scheme was managed throughout by the representatives of the Ministry of Munitions; but there was no production and the shops were not completed by 1920. A scheme was prepared in India which would have more than doubled the existing output in a few months at a comparatively small cost, but it did not appeal to the imagination and was turned down.

Towards the end of last century the administration of the factories was removed from the various Inspectors-General of Ordnance and concentrated in the hands of the Director-General. In 1906 a separate office for the purpose was formed under an officer now called the Director of Ordnance Factories; but during 1918 and 1919 this officer ceased to be under the Director-General and was under the Indian Munitions Board, in which Sir George Buchanan was the Member directly concerned. Now the grouping of all the factories under an officer whose whole time could be devoted to their control was an obvious advantage, but there was one grave defect, it placed one more office between the factories and

the Government of India, and this was the more serious as little decentralisation was attempted. All matters of importance and most financial questions have to be referred by factory to Director, thence to Director-General and by him to the Army Department, which usually has to refer to the finance authority. When the matter leaves the Director's office, it leaves the sphere of technical knowledge, as the education and training of the officials in the Army and Finance Departments have had no connexion with manufacturing methods and conditions. As a result factory accounts, finance, methods and rules have been squeezed within a system devised for branches of the army having nothing in common with a huge manufacturing organisation. Under the Munitions Board there was considerable improvement, as, the Board being itself a Department of Government, the head of the factories had direct access to the ultimate authority; but the temporary nature of the Board militated against permanent changes.

In the old records occur many protests against the administrative system, and its rigidity, centralisation and expense must always have hampered the local executive. There have been many Commissions and Committees, but they do not seem to have got to the root of the trouble. A hundred years ago the standard of public morals was extraordinarily low, and to-day the administrative system appears to be still based on the theory that elaborate regulations and multitudinous checks and counter-checks are needed to prevent fraud. Though a factory superintendent no longer has to attest on oath that he has derived no profit other than his salary, direct financial responsibility is still withheld, accounts are still the masters of management, while regulations become more detailed and voluminous every day, crushing initiative.

True economy in the Army can never result from a cutting down of fighting strength or proper equipment, nor from delays in improving conditions of service; it will come only from a complete overhaul and reform of administration in all branches. One-hundred years ago an army went on service in India with huge crowds of camp followers, even a subaltern has recorded that he had carts and elephants for his baggage, which included a pipe of madeira, in the campaigns of Lord Lake. Crowds of followers no longer hamper the mobility of the forces in the field; but a horde of non-fighting officials, great and small, has settled in every branch of the military service and eats up a huge and disproportionate part of the Army's budget. The business of the Army must be conducted on business lines by men trained for the work and it must be separated from the duties of commanding and of training the fighting units.

A curious feature of Indian administration is its lack of co-ordination and co-operation. While Local Governments were urging employers to improve the housing of their workers, money for sanitary lines for the Ordnance Factories was not forthcoming, though serious loss of output from absence through sickness was clearly shown. When a high Education official wrote an appreciative account of the education facilities provided by certain private mills, the Government factories had no such facilities. When railways were being forced to make better arrangements for the supply of food to their Indian passengers, the Factory Administration was censured for incurring expense in providing space and sanitary fittings for the sale of food to the workers in one factory.

India has allowed industrial towns to develop without much attempt to avoid the evils which any study of the growth of industrialism in Great Britain would have shown to be inevitable unless precautions were taken. Working conditions in many factories, and living conditions in most industrial centres, are most unsatisfactory and far from creditable to the Government of the country.

The Ordnance Factories were the pioneer industrial establishments in India, and to-day they hold a leading place in equipment, organisation and methods and also in variety and quality of production. They can be and might be made a pattern in every respect to the industries of the country and they can and should lead the way in the technical education of the Indian.

Manufacturers in India are asking for protection and the Commission which is now sitting is receiving much evidence of the impossibility of industries facing overseas competition without high protective duties. It is obvious that India imports much which it could itself manufacture, that it exports material which should be worked up in the country, yet labour is cheap, most materials are available at a reasonable price, land can usually be obtained at a moderate cost and

a huge market is close at hand. Why cannot industries using local materials compete with imports from thousands of miles overseas? There are several reasons, but one of the chief, in my opinion, is the cost of management and of skilled supervision, which often swamps the cheap factors. Labour is cheap individually but is dear in the mass, because it is uneducated and needs, for efficient output, a high proportion of skilled supervision. Such supervision has to be mainly European and is most costly, and where money is saved by limiting this class of supervision, more money is lost in quantity and quality of output. Competition with Europe, except under certain favourable circumstances, is impossible for the ordinary Indian factory till the educated Indian has been trained to supervise mechanical work and to take a proper share in the management of industrial establishments. The eight great Ordnance Factories provide an ideal training ground for this purpose and many schemes have been put forward from time to time, and I believe one has at last been sanctioned. If this scheme is broadly conceived, with provision for the training of lads in character as well as for technical education, and if it is for industry generally and not merely for the Government factories, and if the cost is not thrown entirely on the Military Budget, then it will be of the highest importance in the progress of India.

Complete Indianisation of industrial management is impossible, however, in the near future, and it will never be possible till a generation of educated Indians arises, trained in mechanical and engineering sciences, experienced in subordinate management and having the power of studying and of assimilating the industrial progress of other countries. European supervision and management in India is by no means entirely satisfactory, owing to the difficulty of combining up-to-date technical knowledge with experience of Indian conditions. It is distinctly difficult in India to keep in touch with the rapidly changing ideas and methods of the modern industrial world. Competition is too keen to permit of any falling behind and industrialism in India has a constant struggle with the climate and other conditions which exercise an enervating influence on the vast majority of people, both Indian and European.

One important matter which must be touched on is preparation for war. No country can maintain adequate munitions factories in peace time, and in India, where there are no private ordnance factories, the Government establishments must be treated as a cadre, which on mobilisation will be filled out by the commercial workshops. During the later years of the war every effort was made to obtain supplies of war material from private factories but the results were disappointing, due to three causes—there was no power to insist on war work being undertaken, there was hardly a shop which could turn out the accurate work required, and the Ordnance factories were not able to supply the necessary tools, gauges, drawings and assistance. Any sound scheme for the expansion of munitions supply on the outbreak of a great war must ensure, first, that the Ordnance factories are so equipped and organised that they will be able to supply, and continue to supply, gauges, drawings, special tools and materials and assistance for all work which can be done in private shops; second, that private works have such special plant as may be necessary and have annual practice in the work which will be required of them in war time. The special plant might be provided by Government and be used for private work, on condition of its being kept in order and of the staff being periodically trained in war work. The scheme should also provide for a study of the resources of the country, in plant, stocks of goods and materials and also possible sources of supply of raw materials.

It is obvious, I think, that the suggestions made can never be adopted so long as the Ordnance Factories remain purely military and are administered as a somewhat obscure branch of the Army. My view is that all military manufacturing establishments should be brought under a department of Government dealing with supply and be treated as factories and not as branches of the Army. This need not affect military preparation in any way, as Government, acting on the advice of its military experts, would authorise the stocks of equipment and of material to be maintained and would indicate the manufacturing capacity required from the various factories.

I have only touched on the fringe of my subject and have had to omit much of interest in the history of the factories. I am convinced that, in a country like India, the Government factories must be used to the fullest extent in the development of industry on sound lines. Moreover, I am

certain that their efficiency will be greatly increased if their financial needs do not have to compete with the requirements of every other part of the military organisation. I have no doubt whatever that considerable economy will follow if their accounts are treated as industrial and not as military accounts, and if they are placed in closer touch with the ultimate authority.

I doubt whether any branch of the public service in India worked harder or more thoroughly during the war than the Ordnance Factories, certainly no other branch excelled it in economy. My reading of the records and my experience of 28 years in the Ordnance Department lead me to the conclusion that India has usually had far better service from its factory officers than it has paid for. The present age is a logical and material one and the class of man willing to give more than he receives is rapidly vanishing. The Ordnance Factories are a vital link in the defensive chain of India and if they are to be an efficient link, far more attention must be paid to the well-being of the human element. I am proud that I was connected with these factories for nearly 26 years, that I was in charge of their administration for three strenuous years, and that I have had the honour to-day of giving you even this inadequate account of their history and their work.

DISCUSSION.

THE CHAIRMAN, in referring to that portion of the paper which mentioned Sir Arthur Wellesley, and the reflections made on the Arsenal at Seringapatam, said he had in his hands the original document written by Wellesley himself. He had evidently been nettled at the reflections which had been made, and the following was the letter he wrote:

"CAMP, JULY 15, 1803.

SIR,

I have had the honour of receiving your letter of the 27th June, with its enclosures, being letters from Major Norris, upon the subject of the failure of a gun shed constructed by him in the Arsenal of Seringapatam.

I have not with me at present the copy of the Report of the Committee which surveyed the buildings in the Arsenal in October, 1801, nor have I a recollection of the particulars of that Report, or of the state of the buildings which occasioned it. I can answer for myself that I had no intention to cast a reflection upon Major Norris or upon any other officer, or to give the Military Board any impression excepting one of the real state of the buildings examined. I believe the other members of the Committee acted with the same views.

In respect of the gunshed in question, I have to observe that Major Norris, in his letter to the Court of Directors of the 24th November, 1802, declares that the materials employed in its construction were taken from old buildings, and that it could not be expected that they should be good, and that the artificers who built it were very bad workmen. It is probable, therefore, that if he had been a member of the Committee which surveyed the building in 1801, he would have agreed with the other members in the Report which was made.

That shed, as well as other buildings in the Arsenal, must have suffered from the Monsoon in 1801; but as well as I recollect, the Committee remarked that it should be pulled down and re-built with fresh materials, which was the cause of the special report on the subject of its materials and workmanship. The other buildings had suffered only from the monsoon and required what appeared trifling repairs.

I perfectly recollect that stores were placed on the beams of that shed, as I believe they are in every shed in the country, but I never imagined their weight was greater than the beams ought to have borne, otherwise the stores should not have been placed there.

(*Signed*) ARTHUR WELLESLEY, M.G.

The Secretary of the Military Board."

He (General Barrow) thought it might interest the audience to note the personal care which Sir Arthur Wellesley expended on everything that came before him. He had written that letter with reference to a Department under his Command at the time.

COLONEL J. H. LAWRENCE-ARCHER, C.I.E., Ordnance Consulting Officer, India Office, said General Young's paper was mostly historical, and discussions on historical matters were usually either very dull or very controversial. He thought, however, there were a few things which could be learned from the history of the Indian Ordnance factories. One was that those factories had had the same difficulties as everybody else in India had had. People always blamed the Finance Department when they wanted money and did not receive it; but it was a matter of allocation. They got all the money which the nation could afford, and it was in the allocation of that money by the people who were responsible for it that those who needed it were "done down" as they thought. The audience had heard a description of the Indian Ordnance factories, and all that they had done. Not very much had been said about Indian industries. One thought things outside the factory were perhaps small matters—such as the boiling of soap, the making of aluminium hollow-ware, and a hundred-and-one other articles with which the factories were not directly concerned. It struck him that it was perhaps more in the direction of what he might call Ordnance engineering that the Indian Ordnance factories appeared at their best, though as examples of what can be done, they might have their use to industrial establishments; but they were in a peculiar position. They were not like independent industrial concerns; their aim was to produce articles which should be identical in quality, appearance, and in every respect with those produced by the Royal factories at home —Woolwich Arsenal, for instance. They in India came to Woolwich for directions in every possible way; they tried to follow Woolwich even in the methods of manufacture throughout, so that, in the end, their products might be the same as those of Woolwich, and be used throughout the Empire wherever mixed Forces had to operate together. He thought it would be a good thing if a little more liaison could be obtained between the personnel. He had attended prize distributions at Woolwich and had heard the young engineer

who had been trained at Woolwich urged to go beyond the walls of Woolwich Arsenal out into the world in order that he might gain experience and breadth of mind; and it seemed to him (the speaker) that it would be a very good thing for some of these young engineers if they could be sent out to the Indian Ordnance factories with a reasonable assurance that if they behaved themselves and fulfilled the promise of their education, they would be received back again and allowed to resume their job. After all, it would be perfectly easy to send a man of 25 out and to allow him to return when he was 30 and to replace him with a man of 30, who should come home when he was 35 after a five years' tour, and so on. Difficulties would no doubt arise in the case of men of older ages because of certain pension and retiring conditions, but he had no doubt those difficulties could be overcome. The Indian Ordnance factories had adopted apprenticeship schemes and were working hard at them, but there was one great difficulty. At home there were Polytechnics which had professors who taught mathematics. British factories had not to have their foremen going round initiating the lads in the mysteries of the binomial theorem. In India the factory staffs were now actually conducting the education, not of British lads but of Indians, and it would be easily recognised what an extraordinarily difficult task they had. He hoped in the few remarks he had made he had given a lead to an interesting discussion.

Sir Alfred Chatterton, C.I.E., Assoc. M.Inst.C.E., M.I.M.E., thought the author had made out his case that the ordnance factories of India were the pioneers in India of modern industrial developments. They dated back to more remote periods than any other modern industrial organisation in the country. Among his earliest recollections of India were some of these ordnance factories. When he first went to Madras his own offices had been just opposite the Gun Carriage Factory, and he became acquainted with the then Superintendent, Major Fletcher. He frequently went into those factories to see what was going on. Later, when he was endeavouring to introduce the manufacture of chrome leather into India, he became acquainted with the personnel of the factories in which the manufacture of harness and the tanning of leather was carried on, and at about the same time he was associated with General Babington, who was then superintendent of the Cordite Factory at Aruvankad, in the preparation of proposals for the manufacture of acetone in India. With General Babington he had spent a good deal of time over the scheme. The details were worked out to provide acetone for the cordite factory and charcoal for general use, but eventually they had been turned down, partly because of the opposition of the Madras Chamber of Commerce to Government intervention in the matter, and partly owing to the idea which prevailed in Simla that there was no necessity to incur the large capital outlay which the proposals would involve, as the necessary supplies of acetone could then easily be obtained from Germany. Subsequently, as a member of the Indian Industrial Commission, he saw nearly all the other ordnance factories at one time or another, and he was, therefore, in a position to appreciate the difficulties which the officers of the Indian Ordnance Department had to overcome in developing their plans, and he could very heartily congratulate them on the extremely valuable results they had achieved during the period of the war. General Young had shown that in India, as in England, the problem of the munition supply of the country during wartime was one of extreme difficulty. In addition to the difficulties of which the author had spoken, it was probable that future Ordnance officers would have to deal with the question of chemical warfare. That would introduce a new series of problems, and, it was possible, might bring the Ordnance factories still more closely into association with the industrial life of the country.

He was in entire agreement with the author that the greatest obstacle to progress in India was the lack of local Indian engineering talent. Until that was supplied it was perfectly certain that any large and widespread industrial development was impossible, for the reason that in any attempt to compete with foreign manufacturers, although labour was cheap, the cost of supervision was high, and until a very much larger amount of indigenous talent was available in the workshops, and in the higher grades of the administration, the cost of mechanical engineering and analogous forms of primary industrial enterprise in India must necessarily be much higher than it was at home.

One thing the Indian Ordnance factories had had to consider was that of training Indian workmen. It was very greatly to the advantage of India that the Ordnance Department had succeeded in training them to turn out work with the extreme degree of accuracy necessary in modern rifles and ordnance.

It would be a matter, he thought, of interest, and possibly of very considerable value to the country, if Ordnance officers would endeavour to ascertain whence their labour came—whether the artificers in those factories were all hereditary artisans by caste, whether they came from particular districts, whether they were the outcome of the development of railway workshops in the various railway centres of the country, or whether they were just drawn from the ordinary mixed community which congregated in every large town. Nothing very much was known about where those people came from, and it would probably simplify the educational problems of the future if a little more attention was paid to that particular aspect of the labour question.

Another point which Ordnance factories had demonstrated in India was the possibility of mass production of standardised articles. One of

the real difficulties which pioneers of industries in India had to face was the fact that the Indian consumer offering only a very limited market could exercise his own idiosyncracies to an extraordinary degree in the choice of goods that he purchased. He had the supplies of the world open to him, and when he wanted a particular article he could select from dozens of manufacturing firms, all producing articles more or less of the same character but differing in minute detail. So long as that wide choice was allowed to the consumer he would be content to get his goods from abroad. If some system of standardisation could be introduced so that mass production became possible, and the choice of goods was restricted by suitable tariffs, then it would be very much easier to develop manufacturing and industrial concerns in India. For instance, so long as a man could choose from the various range of motor cars made in Europe and America, it was hardly likely that a single factory in India, turning out one particular line of car, would have any prospect of commercial success. The ordnance factories had very clearly proved that the highest grade of production was possible if the work was carried out on a sufficiently extended scale, and, apart from any other work that they had done, that result was of extreme value.

Dr. J. Augustus Voelcker remarked that among the branches of the subject which General Young had dealt with there was one that he had not specially treated of, but to which he (the speaker) as a chemist perhaps might be allowed to refer. The author had told the audience, very rightly, how, at the time of the breaking out of the war, India had failed badly in providing a number of materials of warfare which it might very properly have done, and he had referred also to points of error in administration and to the need of taking a wider view. On all those points he was thoroughly in agreement with General Young. If there was one thing which had been apparent in the last war it was the dependence of our country upon chemical research. That could not be better illustrated than by the noble work of Lord Moulton and his colleagues, and by remembering how great a share these experts had had in bringing about the ultimately successful end. As a member of the Council of the Institute of Chemistry he had been one of those who for a long time had urged upon the Government of India the better recognition of chemists in India. At that time, the Council of the Institute of Chemistry had been constantly receiving representations from the men who had gone out as skilled chemists to India to work in the Ordnance Department, as to the position they held, their status, and their prospects of advancement and retirement. These complaints had been so constant and repeated that the Council of the Institute of Chemistry made very strong representations. In future it would be well, he thought, that more attention should be given to that point. What had been found was that those who had gone out, although they went as experts, on their arrival were treated as very little better than workmen. How could it be expected that such men, with such poor prospects, could do very much in the way of advancement of chemistry as applied to ordnance work? He believed that, as a result of the representations made, some improvement had been effected, but he did think that in the present day, when the Ordnance Department was putting its work into order, the point he had just mentioned should not be lost sight of.

The Chairman, in proposing a hearty vote of thanks to General Young for his paper, said it must have been interesting to all present, because it had not been too technical for those who had no knowledge of the technicalities of ordnance work. There was one remark in the paper which he could not help criticising, namely, that very few high officers of Government ever went to see the various ordnance establishments, and that when they did go they only stayed at the most half an hour. Personally, he had a vivid recollection of a very hot day at the end of March or the beginning of April accompanying Lord Curzon on a visit to either the Cossipore or the Ishipore factory. The visit lasted over an hour and a large number of very pertinent questions were asked by Lord Curzon. He also remembered going round the Pindi Arsenal with another highly distinguished officer, Sir William Lockhart. He would like to say one word about Lieut.-General Stewart of the Bengal Artillery, who was for 20 or 30 years at the Cawnpore Arsenal. Everybody who knew him had the greatest respect for him as a friend, and the greatest admiration for all the good work he did in starting tanning and other industries in Cawnpore. The Indian Ordnance Department had done great work in India—a work which, he thought, had hardly received due recognition. As had been seen on the screen that afternoon, important Government factories had spruug up all over India, and the photographs indicated what big concerns they now were. In the old days they were mostly on a very small scale. The Indian army and the Indian Government had for many years been entirely dependent on the Indian Ordnance Service for the supply of their armies in the field. A great deal of gratitude was due to that Service, whatever criticism it might have received in the press in the dark days of the late war. It had to be remembered that no one contemplated so big a war; and no one should therefore be blamed because those institutions had been wanting when the war began. Even Cabinet Ministers had failed to grasp the fact before August, 1914, that we were up against the greatest war of history.

The Earl of Denbigh, C.V.O., Colonel Commanding Hon. Artillery Co., in seconding the vote of thanks, said that his experience of India was limited to serving in the Horse Artillery there some

30 years ago. but, from very reliable sources, he had heard a great deal about what was going on there, and the paper of General Young was very much to the point, especially with regard to the penny-wise and pound foolish policy which seemed to have permeated Indian administration to an even greater extent than it had done in many of the Departments at home. General Young drew attention to the necessity of separating civilian manufactures from the Military Department. The administration of factory work was a science in itself. The business of the Army must be conducted on business lines by men trained for the work, and it must be separated from the duties of commanding and training the fighting units. He hoped that some of the author's remarks in the paper would be taken to heart by others. Many stories had been related of the extraordinary way in which Indian red tape sometimes operated. A well-known and distinguished general officer had told him how, when a junior officer, he had been on the Quartermaster General's staff in one of the frontier expeditions, and part of his duty had been to buy local supplies from different villages. It could be quite understood that a business of that sort had to be conducted in a somewhat rough-and-ready manner; and the officer to whom he was referring could not do more than send in his indents for cash at different times. The obtaining of receipts and the keeping of proper accounts under the circumstances had been practically impossible. Two years after the campaign had finished, when the accounts of the campaign had been gone through by the finance people in India, this officer had been confronted with a demand for receipts for all the money he had expended in the purchasing of the various supplies. He replied that under the circumstances it was impossible for him to produce them. The reply was, "We are very sorry, but in that case we must make a personal demand upon you to return the money." and he was presented with a bill for £19,000. The officer told him that he settled the matter forthwith by sitting down and writing a cheque for £19,000 on the Army bankers, Messrs. Cox and Co., and sending it in. As it had been well-known that his balance, if there was any at all, was probably more like £19 than £19,000, the Finance Authorities had seen the absurdity of their position. The cheque was never presented and the officer heard no more of the matter.

The motion was carried unanimously, and the meeting terminated.

THE FORESTS OF KENYA COLONY, WITH SPECIAL REFERENCE TO SOME WOODS OF ECONOMIC VALUE.*

By R. St. Barbe Baker (Late Assistant Conservator of Forests, Kenya Colony).

Kenya Colony, formerly known as British East Africa, has a total area of about 245,000 square miles, or roughly speaking twice the size of Great Britain. Although the forest area has not yet been accurately determined, I estimate this to be approximately 2,200 square miles, apart from the extensive areas of bamboo. The most important forests are situated in the Highlands which at one time must have been largely covered by virgin forests; now, as a result of the continuous inroads made by a native agricultural community, these have largely disappeared. The progressive methods of agriculture in the absence of sufficient natural or artificial fertilizer, and the knowledge of crop rotation to secure the recuperation of the soil have accounted for the devastation of vast forest areas. Already in some parts of the native reserves there is a fuel famine and the natives have to travel long journeys to fetch wood.

The small percentage of forest land to the whole area might well give cause for alarm and offers a problem requiring concerted action by the local Forest Department and the Administration. Although a Forest Department has been in existence for a considerable time, little has been done to effect a method of regenerating indigenous species on a comprehensive scale.

In my short experience of two years in the Forests of the Colony I was very handicapped because so little information was available as to yield: in fact no attempt has been made to fix the yield in any way, and there are no working plans.

The virgin forests contain a very large percentage of trees past their prime and, though losing their value each year, they are allowed to stand. The so-called "selection system" generally in vogue is very rough and ready. Timber is felled and extracted by purchasers under leases, licences, or permits, and in all there are about 35 concessions. In practice the selection is actually done by the miller or his agent and not by the forester. The result is that most of the over-matured badly grown and hollow trees are left standing while the best are removed for exploitation. In time the over matured trees fall over and increase the risk of fire or a dense undergrowth, and the absence of suitable seed trees prevents natural regeneration. As far as I could estimate in the virgin forest there is no increase, the annual growth being about balanced by the annual decay. Much of the overmatured forest consists of cedar (*Juniperus procerus*). This is a large evergreen tree, generally found from 60 to 70 feet in height, though under the most favourable conditions it attains to a height of 130 or 140 feet, girthing up to 18 feet. This variety thrives best on mountain slopes at an elevation of from 6,000 to 9,000 feet where there is a rainfall of 40 to 50 inches. Cedar seems to thrive best in mixed forests with *Mu Tamayu* (*Olea chrysophilla*) Olive, *Mu Sengera* (*Podocarpus gracilor*) and (*P. milanjianus*), *Muziga* (*Warburgia ugandensis*) or "greenheart,"

*Reprinted from the *Journal of the Cambridge University Forestry Association*, December, 1923.

Musaizi (*Weihea Africana*) or "Pillar wood," *Mushami* (*Allophyllus abyssinicus*) or "Chestnut," while *Trichocladus ellipticus* (Wych hazel) forms a considerable part of the undergrowth, especially in the more moist places. I have observed that in pure or almost pure, forests, cedar is much smaller and inferior. The Kenya cedar, although somewhat harder than the American pencil cedar, has all the qualities for making thebest pencils. Experiments are now being carried out to perfect a softening process and already success has been met with. To-day several firms are manufacturing pencils from slats imported from Kenya. In the past the bulk of this pencil cedar has come from America, but this source of supply is said to be dwindling and may soon be barred by tariffs; however, there are sufficient supplies of Kenya cedar available to keep up a sustained export in pencil slats and there is no reason why this should not become the chief source of supply for the world.

So far as is known at present cedar is the principal timber likely to be exported in any quantity. Indeed, the Highlands of Kenya may never export timber in bulk owing to the lack of large enough rivers for floating and the high cost of freightage over a long railway journey. Attention should, however, be paid to such varieties as can be utilised for special purposes on the European and American markets. Apart from the one exception of cedar from the Highlands, perhaps the Coast Forests, including the mangrove swamps, afford greater possibilities for the export of timber. Mangrove poles (*boritis*) are amongst the chief exports. The shortage of building material in Persia and Arabia has created a demand for Coastal woods and when the *Moosim Dhows* bring produce to Zanzibar, they call at Milindi and Lamu on their return journey where they pick up mangrove poles in very considerable quantities.

The chief commercial species is locally known as *M'koko*, this is *Rhizoprora mucronata*, while another mangrove of importance is *Ceriops candolleana*. Besides providing building material both for export and the use of the Coast natives and Arabs, the mangrove swamps yield annually large quantities of fuel and bark for tanning.

The land forests of the Coast rise to an altitude of about 1,000 feet, and contain several valuable species of heavy hard woods, which may be of considerable economic value. The chief forests are the *Witu* Forest and the *Arabuko Sokoki*. They contain such trees as *Bembakofi* (*Afezelia quanzensis*) a heavy hard red wood used largely by the Arabs for doors. It can be obtained in planks up to 2 feet in diameter. *M'tanderusi* (*Trachylobium Hornemannianum*) which provides the well-known gum Copal, is also an excellent timber and can be found in large sizes. *Muhuhu* (*Brachylaena Hutshinsii*) is used largely by the Arabs for ceiling beams, and is hard yellowish aromatic wood of some importance. "*Tamarindus indica*" is quite common and might be useful to export for tannery purposes. In England this is popular for making policemen's truncheons and surgical appliances.

The scrub forests of the Coast contain an excellent substitute for ebony in *M'pingo* (*Dalbergia melanoxylon*) African blackwood. Parcels of this wood have already been imported into Europe and have fetched about the same price as ebony. There are also woods which may be suitable as substitutes for boxwood.

As an example of the ignorance which exists of the forest resources of the Coast, it is interesting to note that in the construction Harbour at Kilindini woods from South America are actually being used when a plentiful supply of suitable material easily accessible is within about 150 miles. It is also strange that the new Government Railway on the Uashin Gishu Plateau should be laid on *steel* sleepers and passes through a creosoting yard in virgin forests containing many varieties suitable for sleepers. Again it is hard to explain why huts for workmen should be brought from Norway and constructed in clearings made in the Forests.

A classical instance of Government folly was the construction of a bridge on the Mara River with Baltic pine. This was shipped via London to Kilindini from whence it was transported along 374 miles on the Uganda Railway to Kijabe, where it was met by porters, who carried it on their heads for another hundred miles, to the place where the bridge was finally constructed, hard by a virgin forest containing many species of more suitable woods. Very soon after completion the timber was attacked by bores and fungus, and soon became unsafe and a passing herd of elephant seemed to take great delight in completing the demolition.

Fortunately, there is an increasing tendency to utilise home grown timber, although far too much is at present imported. Better attention will have to be given to seasoning. Carelessness in this respect accounts for much of the prejudice against indigenous varieties which have frequently been adversely compared with imported timbers. Organised research work is urgently required in all branches of forestry and little progress will be made until such time as those officers with a recognised training supersede some of the old timers who, in spite of longer service, possess little practical or technical knowledge.

The first essential is a complete knowledge of Forest Principles which can, with a little experience, be applied to local conditions whatever they may be.

GENERAL NOTES.

International Competition of Designs for Linoleum.—Under the auspices of the *Arte Pura e Decorativa*, an international competition of designs for linoleum will be held at Milan. The designs must reach the "Direction de Revue *Arte Pura e Decorativa*," Via Ciovasso, 4, Milan, not later than the end of March, 1924. The following prizes are offered: one first prize of 5,000 lire; one second prize of 3,000 lire; three third prizes of 1,000 lire each; and other prizes amounting to 4,000 lire. Further particulars can be obtained from the address given above.

The Teak Plantations of Milampur, Southern India.—An account of these plantations was recently given by Mr. R. Bourne, of the Oxford School of Forestry, to the Cambridge University Forestry Association. They were begun in 1840, and have, therefore, passed through all stages, and been regenerated. Their origin was due to need of timber for the Bombay Naval Dockyard, being the first attempt to form forests in India. The silviculture of Teak demands preservation of the qualities of the locality, and so an evergreen understory is necessary. The growth in a short period is very rapid, and accompanied by prolific weed growth, and as weeding has to be carried out, the problem is to do this in the cheapest manner. Tungya cannot be employed as in Burma, because there are no tribes that grow crops on the forest ground. Artificial planting is far cheaper, owing to the regular espacement making the cost of weeding 7s. 6d. per acre, as compared with 40s. when natural regeneration is used. Teak produces much light seed each year, which is collected. The area for regeneration is clear felled, and burnt over to oxidise any acids in the top layer of soil, and destroy roots and seedlings of weeds, thus saving weeding during the first year. Planting is 6ft. by 6ft., and requires a thinning, that is unsaleable, in the third year. A wider espacement resulted in 50 per cent. of the trees being forked at 20 feet, and so had to be abandoned. Weeding is very easy owing to the position of the seedlings being known. The first thinning takes place at 4-6 years, and is mechanical to give an even espacement.

American Settlers in Canada.—According to the Commissioner of the Dominion Immigration Department, during the past year approximately 6,000 Americans have settled in Canada. Their capital is estimated at nearly £250,000. Settlement has, during recent years, been unusually heavy along the newer transcontinental line. One reason given for this is that prosperity is infectious, and that the American settlers are well satisfied with the conditions and opportunities they find in Canada. The tide of emigration from Canada to the United States, on the other hand, is beginning to ebb. Although the population of Alberta has increased from 73,000 in 1901 to nearly 600,000, there are still 108,100 quarter-sections (of 160 acres each) available for free homesteads. The Province has arable land estimated at 72,000,000 acres, of which only 10,550,000 are at present under cultivation.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock:—

February 6.—Iyemasa Tokugawa, O.B.E., First Secretary to the Japanese Embassy, "The Earthquake and the Work of Reconstruction in Japan." (With Cinematograph Illustrations.) Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

February 13.—H. Maxwell-Lefroy, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle." Sir Aston Webb, K.C.V.O., C.B., P.R.A., will preside.

February 20.—Percival James Burgess, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber."

February 27.—Charles S. Myers, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation."

March 5.—Major-General Sir Fabian Ware, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries."

March 12.—Alan A. Campbell Swinton, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.) Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., will preside.

March 19.—R. L. Robinson, Member of the Forestry Commission, "The Forests and Timber Supply of North America." Lord Lovat, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., will preside.

March 26.—Neal Green, "The Fishing Industry and its By-Products."

April 2.—Sir Lynden Macassey, K.B.E., "London Traffic."

APRIL 9.—FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum."

APRIL 30.—BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "Roads."

MAY 7.—J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation."

Dates to be hereafter announced:—

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock:—

FEBRUARY 15.—SIR RICHARD M. DANE, K.C.I.E., Commissioner, North India Salt Revenue, 1898-1907, and Inspector-General of Excise and Salt for India, 1907-09, "Salt Manufacture in India." THE RT. HON. LORD MESTON, K.C.S.I., LL.D., will preside.

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced:—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons at 4.30 o'clock:—

FEBRUARY 5.—F. W. WALKER, "The Commercial Future of the Backward Races, with Special Reference to Papua." SIR GEORGE R. LE HUNTE, G.C.M.G., will preside.

MARCH 4.—THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak." THE RT. HON. LORD BEARSTED will preside.

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

CANTOR LECTURES.

ERIC KEIGHTLEY RIDEAL, M.B.E., B.A., Ph.D., D.Sc., F.I.C., The Chemical Laboratory, The University, Cambridge, "Colloid Chemistry." Three Lectures.

SYLLABUS.

LECTURE III: FEBRUARY 4.—Emulsion Colloids. Preparation and Stabilisation. Coal tar disinfectants, Milks, Phase inversion-biological importance, greases, antigens. Soaps. Ionic micellae.

Adsorbing Gels. Silica gels, ferric oxide and alumina, clays, vaseline, rubber and textiles. Membranes, permeability. Equilibria at membranes, application to leather.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

COBB LECTURES.

Monday evenings, at 8 o'clock:—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 4..Transport, Institute of, at Institution of Electrical Engineers, Savoy Pace, Victoria Ejbankment, W.C., 5.30 p.m. Mr. R. J. Howley, "Road Transport in Relation to the General Transport Problem of the Country."

British Architects, Royal Institute of, at the Royal Society, Burlington House, Piccadilly, W., 8.30 p.m. President's Address to Students.

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Presidential Address by Mr. G. A. Becks.

Chemical Industry, Society of, at the Chemical Society, Burlington House, Picadilly, W., 8 p.m.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Informal Meeting). Mr. F. W. Crawter, "Storage Battery Troubles."

Royal Institution, Albemarle Street, W., 5 p.m. General meeting.

Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W., 4 p.m. Prof. R. H. Biffen, "Modern Wheats."

University of London, University College, Gower Street, W.C., 5.15 p.m. Mr. A. S. Parkes, "The Mammalian Sex-Ratio." (Lecture II.)

At King's College, Strand, W.C., 5.30 p.m. Rev. C. P. Rogers, "Ecclesiastical Music." (Lecture I.)

6 p.m. Mon. R. Nathan, "Dix Années de Recherches: le théâtre libre" (in French).

5.30 p.m. Dr. R. W. Seton-Watson, "A Survey of Bohemian History." (Lecture I.)

TUESDAY, FEBRUARY 5..Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. A. Dendy, "What is Heredity?" (Lecture II.)

Zoological Society, Regent's Park, N.W., 5.30 p.m. 1. The Secretary, Report on the Additions to the Society's Menagerie during the months of November and December, 1923. 2. Dr. N. S. Lucas, Report on the Deaths which have occurred in the Society's Menagerie during 1923. 3. Mr. C. T. Regan, "Reversible Evolution, with Examples

from Fishes." 4. Mr. M. A. Smith, "New Tree-Frogs from Indo-China and the Malay Peninsula." 5. Mr. R. R. Mole, "The Trinidad Snakes." 6. Mary L. Hett, (i.) "On the Family Linguatulidæ." (ii.) "Zoological Results of the Third Tanganyika Expedition conducted by Dr. W. A. Cunnington, 1904-1905: Report on the Linguatulidæ."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Address by Mr. A. L. Coburn.

Anthropological Institute, at the Royal Society, Burlington House, Piccadilly, W., 8.15 p.m. Mr. W. E. Armstrong, "Rossel Island Money."

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Alpine Club, 23, Savile Row, W., 8.30 p.m. Mr. R. P. Bicknell, "Jungfrau, Schallgrat and other Climbs in 1923."

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. J. H. Helweg, "Modern Danish Lyrics, 1870-1920." (Lecture I.)

5.30 p.m. Mr. N. H. Baynes, "The Roman Empire and its Invaders." (Lecture I.)

8 p.m. Miss E. J. Davis, "The City Churches and their Endowments." (Lecture I.).

At King's College, Strand, W.C., 5.30 p.m. Sir Bernard Pares, "Russia before Peter the Great to 1861." (Lecture III.)

5.30 p.m. Dr. H. W. Carr, "The Transition to the Relativist Conception of Nature." (Lecture I.)

5.30 p.m. Mr. J. R. Beard, "Electric Power Mains." (Lecture II.)

5 p.m. Prof. F. C. Burkett, "Christian Beginnings." (Lecture I.)

Physiology, London College of, 8, Taviton Street, W.C., 8 p.m. Dr. J. Lambert, "Camouflage in Nature · Protection of Animals and Insects."

WEDNESDAY, FEBRUARY 6..Anglo-Batavian Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. F. G. Keiller, "The Malay Archipelago."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. (Wireless Section.) Mr. E. B. Moullin, "Atmospherics and their Effect on Wireless Receivers."

United Service Institution, Whitehall, S.W., 3 p.m. Lieut.-Col. D. E. Robertson, "The Organisation and Training of the Army in India."

Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1. Annual General Meeting. Presidential Address. 2. Mr. C. A. Mitchell, "Osmium Tetroxide as a Re-agent for the Estimation of Tannins and their Derivatives." 3. Mr. G. D. Elsdon, "The Composition and Examination of Beef and Malt · Wine." 4. Mr. S. A. de Lacy, An Apparatus will be Demonstrated for Fat Extraction and Solvent Recovery.

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C., 6 p.m. Dr. A. P. Newton. "The Founding of the British Empire."

Archæological Institute, at the Society of Antiquaries, Burlington House, Piccadilly, W., 5 p.m. Mr. F. J. Lovegrove, "The Cathedral Church of Llandaff."

Sanitary Engineers, Institution of, Caxton Hall, Westminster, S.W., 7.30 p.m. Dr. W. Rushton, "The Life Present in a Stream and the effects of Sewage and Various Trade Wastes on it."

University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. P. Geyl, "Mediæval Dutch Drama."

5.30 p.m. Mr. I. C. Grondahl, "Contemporary Norwegian Literature." (Lecture I.)

5.30 p.m. Mons. P. Vitry, "Les Sculptures de la Cathédrale de Reims." (In French.)

At the London School of Economics, Houghton Street, Kingsway, W.C., 5.30 p.m. Mr. F. J. C. Hearnshaw, "The Political Expansion of the Empire."

At the University, South Kensington, S.W., 5 p.m. Sir Frederick Bridge, "Some Shakespearian Studies" (Lecture III.)

At King's College Strand W.C. 5.30 p.m. Mr. A. F. Kendrick "The Artistic Background of Mediæval History." Textiles.

THURSDAY, FEBRUARY 7..Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Squadron-Leader R. B. Maycock, "Airmanship at Sea."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. Sir William Bragg, "Recent Research in Crystalline Structure." (Lecture I.)

Mechanical Engineers, Institution of (Midland Section), Technical Institute, Coventry, 7.30 p.m. Mr. R. Jackson, "Pulverised Coal, its Preparation and Utilisation."

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Linnean Society, Burlington House, Piccadilly, W., 5 p.m.

Chemical Society, Burlington House, Piccadilly, W., 8 p.m. Messrs. N. V. Sidgwick and R. K. Callow, 1. "The Solubility of the Aminophenols." 2. "Abnormal Benzene Derivatives."

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. H. G. Dowling, "Modern Considerations attaching to Wall Paper Decoration."

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C., 5 p.m. Sir H. L. Smith, "The Economic Laws of Art Production." (Lecture IV.)

University of London, University College, Gower Street, W.C., 5.30 p.m. Senator Prof. Antonio Cippico, "Il Polliziano."

5.30 p.m. Mr. I. Björkhagen, "Modern Swedish Prose Authors." (Lecture I.)

5.30 p.m. Prof. J. E. G. de Montmorency, "Comparative Customary Law of Europe and Asia." (Lecture III.)

At King's College, Strand, W.C., 5.30 p.m. Prince D. S. Mirsky, "The History of Russian Literature." (Lecture III.)

At Bedford College, Regent's Park, N.W., 5.15 p.m. Mrs. H. A. L. Fisher, "The Economic Position of Married Women Under the Law."

At the London School of Medicine for Women, Hunter Street, W.C., 5 p.m. Prof. W. C. Cullis, "Respiratory Exchange." (Lecture III.)

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Miss Grace Owen, "The Present Prospect of the Nursery School."

FRIDAY, FEBRUARY 8..London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Lieut.-Col. C. B. Levita, "Slum Areas in London."

Royal Institution, Albemarle Street, W., 9 p.m. Sir Arthur Evans, "Minoan Art of Crete."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Mr. R. W. Wilson, "Repair and Upkeep of Pneumatic Tools."

Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W., 8 p.m.

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W., 6.30 p.m. Mr. R. C. Chadwick, "Aeroplane Performance Estimates."

Timber Trade Lectures, London Chamber of Commerce, Oxford Court, Cannon Street, E.C., 6.30 p.m. Mr. H. A. Pritchard, "Forestry."

Physical Society, Imperial Institute of Science, South Kensington, S.W., 5 p.m. Annual General Meeting.

University of London, University College, Gower Street, W.C., 5.30 p.m. Dr. D. Heron, "Business Forecasting."

5.15 p.m. Dr. B. Hart, "Psychology and Medicine."

At King's College, Strand, W.C., 5 p.m. Dr. W. D. Lang, "Some Palæontological Evidence with regard to Evolution." (Lecture II.)

Prof. R. W. Seton-Watson, "The Rise of Nationality in the Balkans." (Lecture III.)

Photographic Society, 35, Russell Square, W.C., 7 p.m. Lantern Lecture.

SATURDAY, FEBRUARY 9..Royal Institution, Albemarle Street, W., 3 p.m. Dr. R. S. Rait, "The Last Years of the Scottish Parliament." (Lecture I.)

Journal of the Royal Society of Arts.

No. 3,716. VOL. LXXII.

FRIDAY, FEBRUARY 8, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, FEBRUARY 13th, at 8 p.m. (Ordinary Meeting.) H. MAXWELL-LEFROY, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle." SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., will preside.

FRIDAY, FEBRUARY 15th, at 4.30 p.m. (Indian Section.) SIR RICHARD M. DANE, K.C.I.E., Commissioner, North India Salt Revenue, 1898-1907, and Inspector-General of Excise and Salt for India, 1907-09, "Salt Manufacture in India." THE RT. HON. LORD MESTON, K.C.S.I., LL.D., will preside.

EIGHTH ORDINARY MEETING.

WEDNESDAY, JANUARY 30th, 1924; SIR HERBERT JACKSON, K.B.E., F.R.S., in the Chair.

The following candidate was proposed for election as a Fellow of the Society :—

Aslam, Syed Mohammad, B.A., Oxford.

The following candidates were duly elected Fellows of the Society :—

Alexander, Philip, London.
Fletcher, John Kyrle, Newport, Mon.
Graydon-Bradley, Mrs. E., London.
Margerison, William Joseph, Leeds.
Rhead, Frederick A., Wolstanton, Staffs.

A paper on "The History, Development and Commercial Uses of Fused Silica" was read by SIR RICHARD ARTHUR SURTEES PAGET, Bt.

The paper and discussion will be published in a subsequent number of the *Journal.*

CANTOR LECTURE.

On MONDAY, FEBRUARY 4th, 1924, DR. ERIC K. RIDEAL, M.B.E., B.A., D.Sc. F.I.C., of the Chemical Laboratory, The University, Cambridge, delivered the second lecture of his course on "Colloid Chemistry."

On the motion of the CHAIRMAN, MR. WALTER C. HANCOCK, a vote of thanks was accorded to Dr. Rideal for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

DOMINIONS AND COLONIES SECTION.

TUESDAY, FEBRUARY 5th, 1924; SIR GEORGE R. LE HUNTE, G.C.M.G., in the Chair.

A paper on "The Commercial Future of the Backward Races, with special reference to Papua" was read by MR. F. W. WALKER.

The paper and discussion will be published in a subsequent number of the *Journal.*

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "Nitrates and Ammonia from Atmospheric Nitrogen," by Mr. E. KILBURN SCOTT, A.M.Inst.C.E., M.I.E.E., have been reprinted from the *Journal* and the pamphlet (price 3*s.*) can be obtained on application to the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2.

A full list of the lectures, which have been reprinted and are still on sale, can also be obtained on application.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows wishing to bind their annual volumes of the *Journal,* cloth covers can be supplied, post free, for 2*s.* each, on application to the Secretary.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained by Fellows on application to the Secretary.

ROYAL SOCIETY OF ARTS.

INDIAN SECTION.

FRIDAY, JANUARY 18TH, 1924.

SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., in the Chair.

The paper read was :—

THE SURVEY OF INDIA.

BY

COL. H. L. CROSTHWAIT, C.I.E., R.E., retd.,
Formerly Superintendent, Survey of India.

It is just eight years since my former chief, Sir Thomas Holdich, delighted an audience in this theatre with an address on the "Romance of the Survey of India." I cannot hope to emulate the charming and picturesque language with which Sir Thomas habitually adorns his addresses, nor can I treat you to much "romance," for the task I have before me this afternoon is to endeavour to give you an idea of how the survey of a great country is carried out ; how its maps are made ; and the nature of the scientific work undertaken by the Survey of India. It will, of necessity, only be an outline of the many enterprises with which this great organisation is concerned.

Let us glance for a moment to the size and extent of the country with which we have to deal. The Indian Empire covers an area of rather more than 1,800,000 square miles. This is about fifteen times as large as Great Britain and Ireland. Nevertheless, such is the enormous size of the British Empire that it is only about one-eighth of the whole. If we superpose an outline of India on that of Europe, placing Koh-i-Malik Siah, which is the trijunction of India, Persia and Afghanistan, on the coast of Scotland, then the eastern boundary of the Empire will fall in the Caspian Sea, and, locating Cape Comorin in Greece, the northern confines of India will touch Lapland. But the work of the Survey of India does not stop at the frontiers of the Empire—for it is concerned with the mapping of the adjacent countries of Arabia, Mesopotamia, Persia, Afghanistan, Turkistan, Tibet, and a part of China, and it has mapped Somaliland in Africa.

These countries have, however, not been mapped in the same rigorous way that India has been surveyed, and, with the exception of considerable areas in Mesopotamia and Persia, which were more or less rigorously surveyed during the Great War, the external maps of India depend on hasty military surveys carried out during various campaigns, as opportunity presented itself, and for the larger part on travellers' reports and reconnaissances and from every other available source.

In fact no military expedition has been undertaken on, or beyond, the Indian frontier which has not been accompanied by surveyors. These maps are available on the millionth scale.

The Survey of India, like other great survey organisations, had its origin in the necessity for maps arising from military operations. Though there had been detached surveys during the early wars of Clive, it took a permanent shape with the appointment, in 1764, of James Rennell, who later became the celebrated geographer, as Surveyor in Bengal, and as Surveyor-General in 1767. Rennell based his work entirely on traverses, distances being chained and checked by astronomical observations. He covered with his surveys the area then in occupation of the British in India, and extended them even as far as Agra. The scale of his Bengal Atlas, published in 1779 and lately reproduced in Calcutta, is one-inch to five miles—a copy of which is on the table. Rennell retired in 1776, and in 1778 he brought out the first approximately correct map of India. D'Anville's map had already appeared in 1754, but, owing to lack of material, it had little pretensions to accuracy. But his map is certainly of historic interest as showing what was known of India at the time Rennell started work. The Royal Geographical Society possesses copies of this map.

As Rennell had been the father of Indian geography, so Colonel Lambton was the father of Indian Geodesy, and the originator, in India, of the true foundation on which topographical mapping should rest. It was not until the end of the eighteenth century that triangulation was recognised as the true basis for accurate mapping. Also, our Indian possessions had grown to such an extent that methods which were passable where comparatively small areas are concerned became inaccurate when applied to a large country. Lambton was an officer of the 33rd Regiment, and it was largely due to Sir Arthur Wellesley—at that time commanding his regiment—that

he was able to put forward his scheme for the substitution of triangulation for traversing as the basis of survey operations. Lambton began work in 1802, not without opposition to the new method of triangulation as opposed to traversing, and his position was not recognised until 1818 when he was appointed the first Superintendent of the Trigonometrical Survey. He carried out the net-work triangulation in the neighbourhood of Madras shown on the index chart, Fig. 1. He died in 1823 at the age of seventy-two while at work in the field—being succeeded by his assistant, Sir George Everest. From this time onward the operations of the Survey of India have been recorded in a series of great volumes and reports which form a library in themselves.

For our purpose it is convenient to divide the operations under three heads :—

1. Geodesy.

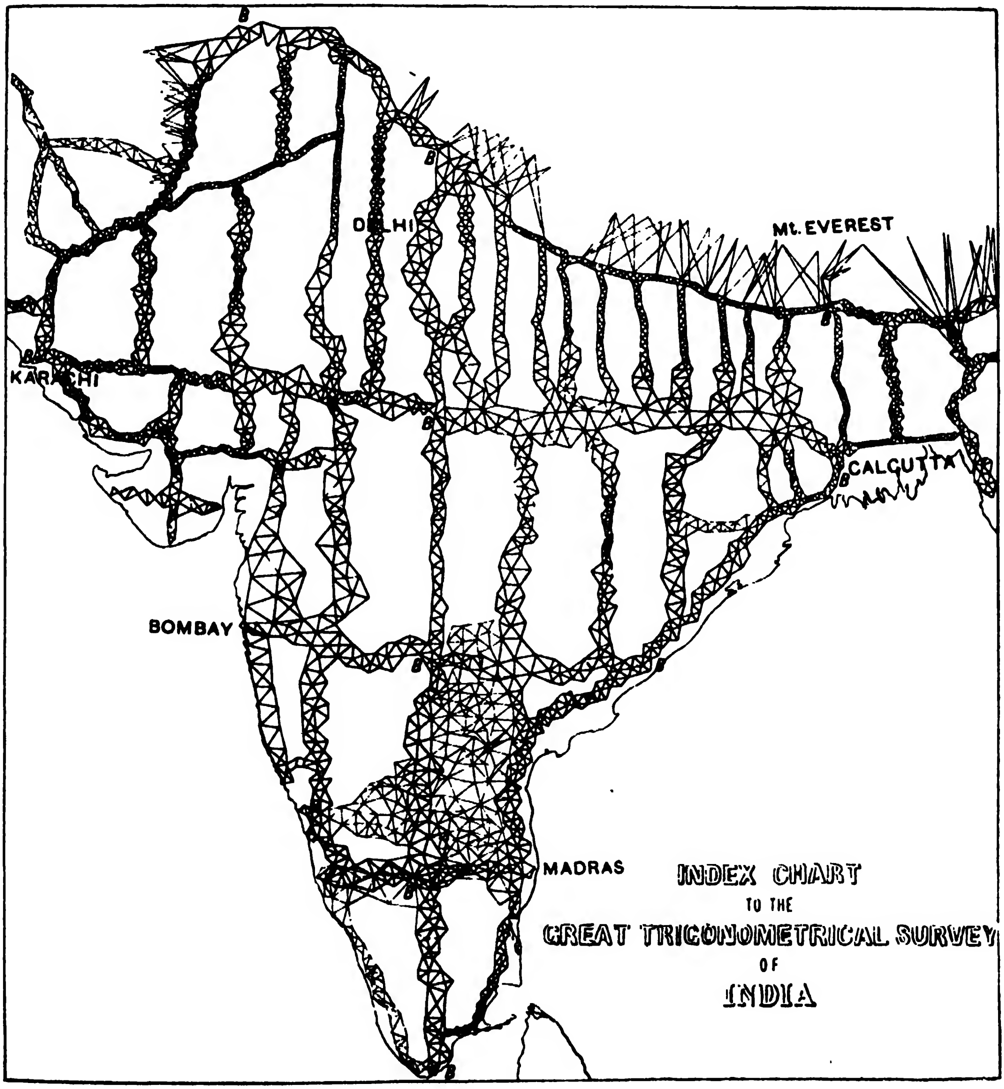

Fig. 1.

2. Topography and the drawing of the fair map.

3. The Reproduction and Printing of the map.

The Geodetic Branch which is represented by the Great Trigonometrical Survey is concerned primarily with the fundamental operations of survey, namely, the con-

struction of the foundation for the topographical work which is to follow. This consists in the determination with the greatest possible accuracy of the latitude and longitude of a number of points, permanently fixed on the ground, by means of first-class triangulation, and, at the same time, the determination of their heights controlled by spirit-levelling of precision.

But, in another aspect, geodesy is one of the most fundamental of sciences, for it concerns itself with the measurements of arcs of the meridian which, combined with arcs measured in other countries, give the means of determining the size and shape of the earth—a knowledge of which is essential for so many different operations. Geodesy, therefore, is a science of international importance. We have here a chart of the Great Trigonometrical Survey of India as devised by Everest. Though Lambton's method of triangulation was a great advance on that of Rennell (shown in the neighbourhood of Madras), his network introduced certain technical difficulties. It was not easy to adjust those errors of observation and of instruments to which all human endeavours are susceptible, nor, indeed, was it necessary to cover the *whole* country with points fixed with such great accuracy involving an inordinate expenditure of time and money. Sir George Everest devised a system which obviated these drawbacks. To him we owe the introduction of methods far ahead of his times and geodesy remains to this day more indebted to him than almost any other person. He conceived the idea of superseding the net work triangulation by meridional and longitudinal chains of triangles to cover the country in the form of a gridiron. They followed selected meridians and parallels of latitude enclosing quadrilateral figures, so that the chains closed on themselves, thus affording a means of distributing errors which must be generated no matter how carefully the work is carried out. This system has remained in vogue to the present day. The origin of the Survey of India is at Kalianpore in Central India, near the Sironj Base. It was here that Everest established an observatory in order to fix, by astronomical observations, the position which determines the location of India on the earth's surface.

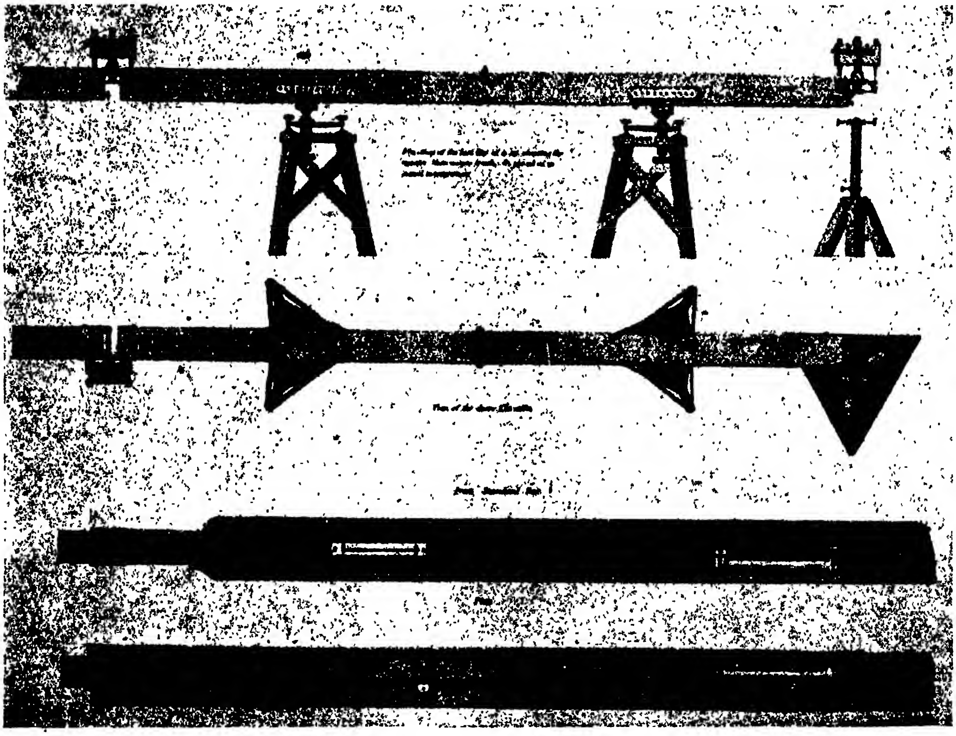

FIG. 2.—Colby Base Line Apparatus.

Where the triangles are carried across the flat plains, they are small and have short sides—it being necessary to use towers to extend the field of view of the observer. In hilly country they are, of course, as long as possible. The central spaces enclosed by the quadrilaterals are filled up by secondary and tertiary triangulation in order to provide sufficient points for the plane-table surveyors to construct the detailed maps.

This triangulation is carried out by smaller instruments and is of a lesser degree of accuracy than the geodetic work on which it is based, but, as will be seen from an inspection chart, it is never necessary to go far from the controlling points. In flat and enclosed country traversing has to be resorted to in order to provide points for the plane-tablers, but, as before, it is controlled by the primary triangulation which is never far off.

The chain of triangles extending up the centre of the chart from Cape Comorin to the Himalayas is the meridional arc known as the "Great Arc." The portion lying between Bangalore and the mountains was used by Everest for the determination of the elements of the earth. It is nearly thirteen hundred miles long and embraces 21° of latitude. The triangulation is controlled by ten bases which are marked "B" on the chart. They are distributed as equally as possible over the whole area. These bases were measured with the greatest possible accuracy by an apparatus devised by Colonel Colby, R.E. (Fig. 2.) It consists of a series of compensated bars, each ten feet long, which, supported on trestles, are placed end to end, though not actually touching each other. They are, however, made optically continuous by a pair of microscopes—so mounted as to bridge the interval between the bars, the distance apart of the microscopes being accurately known. The bars can be moved horizontally and laterally in order to obtain correct alignment by means of slow motion screws which actuate the platforms on which they rest. As the ground had to be levelled for the reception of this apparatus, and the bars were cumbersome and expensive to work with, they will never be used again, and now are only of historic interest. In future, bases will be measured with invar tapes. The existing bases are about seven miles long. Future ones, using the invar tape where level ground is not necessary and rapidity of measurement is much greater, will be considerably longer—up to fifteen or twenty miles.

Photo by C. D. Simons.

FIG. 3.—Nojli Tower.

A station of the Great Trigonometrical Survey, in the plains of India, near Roorkee, from which several Himalayan peaks were observed.

The original triangulation was carried out with theodolites 36 inch and 24 inch in diameter and having five reading microscopes. The tripods on which they stood were, except in the case of rock stations, supported by specially constructed isolated masonry pillars. The modern substitute for these theodolites has a 12 inch graduated arc and three reading microscopes.

The geodetic triangulation gives extremely accurate, and, for topographical purposes, errorless, values of the latitude and longitude of the points shown on the chart. Their heights are controlled by means of spirit levelling of the highest precision which has its origin at mean sea-level determined by tidal observations. This is carried out in duplicate by independent levellers with permanent bench-marks every few miles apart, and with special standard bench-marks at important places. These bench-marks are largely made use of for irrigation and other engineering purposes.

Besides the provision of data as described, the geodetic branch undertakes a series of tidal observations with self-recording tide-gauges for the determination of tidal constants by harmonic analysis, from which

are constructed the tide-tables for the use of shipping in Indian waters. Tables for forty ports are computed by the Survey of India and are issued a year in advance, showing the predicted time and height of the high and low water throughout the year. They include the ports of Suez, Bushir, and Basrah, outside India.

The trigonometrical branch has undertaken a magnetic survey of India which has recently been completed—though certain self-recording stations, registering the declination, horizontal force, and vertical force, are still maintained. A number of repeat stations are also visited every year with a view to ascertaining secular changes.

There are two allied investigations by the survey of India which are of great interest to us all, as they relate to the constitution of the earth's crust on which we have to pass our existence, namely, gravimetric observations to determine the force of gravity, and investigations into local attraction. The chief object of gravity measurements is to give an idea of the relative distribution of the density of matter on the earth's crust. An unequal distribution would mean that the general equilibrium, or balance, of the material composing the crust was upset, and, in consequence, the crust itself might be in a state of strain. As in nature there is always a tendency towards adjustment, so that to bring things back to a state of equilibrium we might expect earth movements in such regions.

Fig. 4.—A triangulation station on the Pamirs.

More has probably been written regarding the phenomenon known as local attraction than on any other geodetic subject. Local attraction exhibits itself in the effect it has on verticality of the plumb-line especially in the neighbourhood of mountain masses; but a deflection of the plumb-line means a corresponding, apparent displacement of

the zenith, and, since the declination of the zenith is equal to the latitude of the place, local attraction affects all astronomical latitudes.

The Himalayan Range, with the Tibetan Plateau lying to the north of it, forms by far the greatest topographical feature on earth. For this reason, India presents especial facilities for the study of local attraction. Surveys at the foot of the mountains show that this great mass has an enormous effect on the plumb-line. Let me try to explain how it is possible to ascertain that the plumb-line at the foot of the mountains is drawn towards them. Suppose we go south into Central India to Kalianpore—four hundred and thirty miles away from the hills and outside the attraction of the now far distant mountains—and observe an astronomical latitude there. Then we shall have, we hope, a latitude uninfluenced by local attraction. This we call our "initial latitude." Now we can ascertain an independent latitude for a point at the foot of the mountains, based on the latitude of Kalianpore, by measuring the actual distance between the two places on the earth's surface through the medium of a chain of triangles, such as you have already seen, depending on the measurement of horizontal angles which are not influenced by local attraction, for it is only vertical angles that are affected.

Latitude brought up in this way is called the geodetic latitude, as opposed to the astronomical latitude, which, as already mentioned, is dependent on the declination of the zenith. The difference between the two latitudes is the amount of local attraction. The point to be emphasised about local attraction is not that the plumb-line is deflected towards the Himalayan mass, but that it is not deflected nearly as much as the combined visible mass of the mountains and the Tibetan Plateau would appear to warrant. To take a concrete example—the deflection at Dehra Dun at the foot of the Himalayas is 31″. As one second of arc is equal to about one hundred feet on the earth's surface, this represents three thousand one hundred feet. You would be that amount out if you had to depend for your position on the astronomical latitude only, and no maps based on it would be accurate as regards location of places on the earth's surface where local attraction existed. Now, if we compute what the deflection of Dehra Dun should be, taking into account the apparent masses lying around, it works out to 86″, whereas it is really only 31″. What is the cause of this difference? Now, one of the most difficult problems the geologist and geodesist had to deal with was how the earth's crust, which has little inherent strength, can support such an enormous weight as the Tibetan Plateau—some three miles high above sea-level and several hundred miles wide. The theory of Isostasy, which the study of local attraction has

FIG. 5.—Survey station, Koh-i-Malik Siah.

called into existence, comes to the rescue, and puts forward the suggestion that mountains are, as it were, floating like icebergs in a kind of molten interior—or, to put it in another way, if they are not actually floating, they are constructed so that they would float. This is brought about on the supposition that the extra protruberance is compensated for by a defect of density below in the roots of the mountains, and it is this point that plumb-line observations bring out. Whatever the process which was at work in the building of mountains of Isostasy assumes, and observations for local attraction seem to show that compensation does exist. If the mass north of Dehra Dun were completely compensated, according to the theory, it has been computed that the deflection would be only 18″, but, as we have already seen, it is actually 31″—so that, if this theory be correct, the Himalayas (in this neighbourhood) may be said, in terms of plumb-line deflection, to be short of compensation by 13″. But this mass represents the result of the greatest convulsion the earth has ever experienced—

Fig. 6.—Surveying in Garhwal.

causing great masses of enormous weight to stand up above the general level of the earth, it has also brought about a compensating deficiency below them—thereby making it possible for mountains to exist without putting the crust to any very considerable strain. Now, this so-called compensation is supposed to extend to a certain depth above which columns of equal sections of the earth's crust have equal weights, no matter whether they emerge at the surface of the Tibetan Plateau—three miles high—or at sea-level. This is what the theory anyhow, in its present state—so that, while there may be a tendency towards isotatic equilibrium, it may not be so far advanced in India as in other places—for instance, in the United States, where mountains are older and where this compensative action action has been longer at work. It might follow that the Tibetan mass, not being completely compensated, is not in a condition to float freely, and has, therefore, to receive a measure of support from the crust. This would have the effect of setting up strains, and may be a contributive cause to the

frequent earthquakes which occur in this mountainous region—but here we enter the realms of pure speculation.

How mountains are built up in the first instance, and how the compensation which allows them to exist came about, are, as yet, unsolved problems. The explanation which the theory of Isostasy offers may be correct, but the problem is far from simple and requires extended investigation before any conclusive results are arrived at.

It is often easier to make observations than to give them a correct interpretation. This especially applies when we attempt to unravel the hidden workings of the earth's crust. It should be mentioned that the description of local attraction here outlined has been shorn of many complications. It has been stated, with some truth, that the investigation of this problem has been more prolific in giving birth to new problems than in solving old ones. Too much space has, perhaps, been devoted to this question, but every investigation in this connection is of vast importance and interest.

We must now pass to the next division of our subject, namely, topography.

Detailed mapping in the field is carried out entirely by means of the plane-table, which is a simple instrument admirably suited for small scale work such as is carried out in India. On it, the triangulated, or traverse points, are plotted in their correct position, with their heights written in. With the help of these surveyors can fill in the topographical details, including the contours, with little or no direct measurement, by means of the method of re-section; but, plane tabling is not, by any means, a mechanical operation. It requires, to produce good results, considerable artistic skill, good draughtsmanship, and long practice, combined with an "eye for country." The plane-table work is normally carried on in the field on the one-inch scale. This is subsequently enlarged by photography to one-and-a-half-inch to one mile, and blue prints are made from the field sections on drawing paper, and on this scale the work is fair-drawn in black.

Two fair sheets are drawn—one for the details of the map, and one for the contours only. For technical reasons it is necessary to separate in the first instance the contours from the detail. The completion of these two sheets with the addition of the "colour pattern" showing the colours in which the different features appear on the printed map, ends the work of the field party. The surveying is carried on in the cold weather, and the fair drawing of the work done in the hot season, a suitable division of work in a country like India.

The third, and last, division of our subject relates to the reproduction and printing of the map in colours. The original fair sheets, when received from the field party, in the reproducing office, are photographed, and at the same time reduced by one-third, namely, in the case of the normal map to the one-inch scale, that is, back to the scale of survey. This applies both to the detail and the hill sheets. The object of the reduction is to sharpen up the line work and lettering of the map. From the negative of the detail sheet copies on glass are made by a process of contact printing. From these copies are then selected, one for each colour—red: roads and villages; blue: water forms; black: names, and so on. The example shown is one selected to serve as the red copy. Using the "colour pattern," already mentioned, as a guide, everything is painted out except those items which are to appear in red on the printed map. This process is repeated in turn on the copy selected for each colour. We now have a series of negatives each representing a different colour. From these a similar number of zinc plates are prepared by the helio-zincographic process, all of exactly the same size (since they were all made from the same original), so that, when printing takes place, each colour falls in its correct position. These plates are then inked up in the appropriate colours and the map is printed from them, thus combining the various colours. All this time the contours have been kept apart, as it would complicate matters too much to attempt to paint them out had they not been separated in the first instance, as already described. This is the reason that a separate contour sheet is drawn. A zinc plate is now made in the same way as for the colours, and the contours are sur-printed in brown. The result is a finished map of each, some specimens of which are exhibited.

The foregoing is a mere outline of the method employed. There are, of course, many details connected with the process to which it is impossible to refer. The maps themselves afford the best evidence of the excellent work now produced by the Survey of India.

The Indian maps used for general administrative purposes are on the one-inch and half-inch scales. There is also a series on the quarter-inch scale. The maps of India and Adjacent Countries are on the millionth scale, or about one inch to sixteen miles. There is a series covering the same area but conforming to the requirements of the International Map of the World, to which the Indian Survey has contributed a large number of engraved sheets. There are many other maps which have been brought out for special purposes too numerous to refer to here.

A very complete and interesting exhibit of maps will be on view at the British Empire Exhibition next April.

In conclusion, I should like to say a few words as regards the future of scientific work in India. Even in these days of financial stringency there will probably not be much difficulty in getting funds for map making—for the reason that the necessity for maps is fully recognised, though, from motives of economy the scale of survey may suffer a reduction to a dangerous point. Let us hope that no effort will be spared to continue the world-renowned scientific work of the Survey of India the foundations of which have been so firmly laid by Everest, Walker and Burrard.

DISCUSSION.

The Chairman (Sir Thomas H. Holland), in opening the discussion, said Colonel Crosthwait's paper, like the Department which he represented, left very little scope for criticism. From the title of the paper no doubt many of the audience had anticipated references to other Surveys of India like the Marine Survey, the Botanical Survey, the Geological Survey, and the Archæological Survey, but there was really only one department which was known, and properly known, as *the* Survey of India. There were many Government Engineers, but Colonel Crosthwait and some of his colleagues would state that there was only one Corps of *Royal* Engineers. His thoughts were turned by one sentence in the paper: Colonel Crosthwait said: "It is often easier to make observations than to give them a correct interpretation." Experience showed that, on the other hand, the temptation to produce an interpretation was what many scientific men yielded to rather than the dull path of simple observation. It was not easy to make observations, and to continue doing so regardless of theoretical consequences, without any idea of what the observations might mean. It was in the cold and mechanical operation of recording observations that the Survey officer excelled. He knew that his map would not be judged by its artistic general appearance, but by critical and microscopic examination of each purely local detail—by the geologist, by the irrigation officer, by the railway engineer, and even by the tired pedestrian. He also knew that nine out of ten among those who used his map and found it useful accepted its usefulness as a matter of course, requiring neither praise nor comment, but he knew that the tenth man who found a microscopic error proclaimed the great inconvenience to which it had put him. Yet that error might be due to any one of the many who had specialised shares in the production of the map. So the Survey officer had to be not only meticulously accurate for his own sake, but he had to be silently loyal to his team. The audience were no doubt wondering what he (the Chairman) was driving at. It was this. There were two main phases of scientific operation. First, there was the making of observations, and, secondly, the theoretical speculations which followed. For the first stage, blind, rigid discipline was required of the Survey staff. For the second stage imagination and freedom from the bonds of orthodoxy might be sometimes necessary. It was, then, possible to see what had been the foundation policy which had been consistently maintained for over 150 years in staffing the Survey of India. The Survey of India had been staffed by officers who had the necessary scientific foundation but who had had drilled into them also that form of discipline which hitherto among English people had been attainable only in our fighting Services. So far as mere maps and mere records were concerned, any experienced critic would say that those products of team discipline in India compared favourably with those of the most civilised countries of the world. What about the other side? Had that faithful adherence to mechanical necessity dulled the imagination of the Survey officer? Had he neglected the purely scientific and theoretical by-products of his work? Anyone at all acquainted with the history of the Survey could point to a succession of officers who had become distinguished in the world of geographical exploration, sometimes in the world of mathematical research, and especially, in recent years, in geodetic speculation,—men like Sir George Everest, the Thuilliers, Sir Sidney Burrard, Sir Gerald Lenox-Conyngham, Colonel Ryder and Colonel Crosthwait. Coming to the Home Survey there was the same type of officer, but working under quite different conditions, for instance, Alexander Ross Clarke, who had received the Royal Medal of the Royal Society before even he had been elected a Fellow. Any geodesist, English or foreign, would as soon think of travelling without Ross Clarke's treatise as a Bishop would think of undertaking an Episcopal visitation without a prayer book. Ross Clarke's figure of the earth had remained the standard figure for all geographers, until more recent gravimetric observations had rendered necessary quite minor and local corrections. On the scientific side ideas had not always originated among Survey officers. The theory

of mountain compensation had not originated with the Survey, but with Archdeacon Pratt, of Calcutta, who had speculated on the faithfully recorded and very accurate results of the Survey measurement of the great Indian arc; but it had required Survey officers, like Sir Sidney Burrard, Sir Gerald Lenox-Conyngham and Colonel Crosthwait to show that Archdeacon Pratt was not quite right. In 1889, Captain Dutton, of the United States Navy, presented Pratt's theory in a new form. He gave the idea an orthodox baptism, and a name, which seemed to be necessary always for the respectable life of any scientific theory, namely, the theory of isostasy, to which Colonel Crosthwait had referred. The Survey officers in India, however, showed that isostasy could stand unmodified only when the observations were very few, or were wanting in the precision which was customary in the Survey of India. Then G. K. Gilbert of America, a distinguished geologist, had explained the anomalies which were observed by pointing out, in 1913, that whilst each column of the earth's crust might be in isostatic equilibrium with all the others, the mass might be unevenly distributed vertically, so that the plumb-line and pendulum would be affected differently by columns of exactly the same total weight in different areas. The credit for that ingenious suggestion had been given to G. K. Gilbert all the world over, but if one read one of the professional papers of the Survey of India, No. 13 of 1912—one year before G. K. Gilbert published his paper—one would find the following remark—which was only given parenthetically as if it was a sort of passing thought: "Assuming the doctrine of isostasy to hold, is it not possible that in any two columns of matter extending from the surface down to the depth of compensation there may be the same mass, and yet the density may be very differently distributed in the two columns? These two columns, though in isostatic equilibrium, would act differently on the plumb-line owing to the unequal distribution of mass. The drawback to treating this subject by hard-and-fast mathematical formulae is that we are introducing into a discussion on the constitution of the earth's crust a uniform method when, in reality, probably no uniformity exists." That had been published without any fuss in India one year before G. K. Gilbert's theory, which had attracted so much attention, was published in America. He thought it was fair to call attention to it because the Gilbert Theory was so continuously quoted in geological literature. He might also tell the audience that the author of Professional Paper No. 13, in 1912, was Colonel H. L. Crosthwait. He did not think it would be difficult to show that organisation and the execution of observational work, which formed nine-tenths of all Survey work, and which was the outcome of a rigid discipline, had not inhibited the scientific imagination of its officers. They had taken their line of conduct from the first great Surveyor-General, Major James Rennell, who, with one European and one Armenian, had produced the first reliable map of Bengal, and who, at the mature age of 23, with four European officers, had been entrusted with the duty of undertaking the larger task of a general Survey of Northern India.

He had brought with him a very interesting document, which was a reproduction of James Rennell's Journals—the Journals he took with him when he retired from India. They had been sent out by Sir Rennell Rodd, who was then Ambassador at Rome, and who was a great grandson of Sir James Rennell, to the Victoria Memorial. When they had come into his own hands as a Trustee of the Memorial, he had thought them of sufficient interest to have them carefully edited and published as a separate memoir by the Asiatic Society of Bengal. He thought that memoir, which had been very faithfully edited by Mr. La Touche, of the Geological Society, was a most interesting document indeed. He would read one section in which he was sure the audience would be interested:

"Letter to the Court of Directors, March 30, 1767." (It was an apology for having to pay a very large salary to the new Surveyor-General)—"So much depends upon accurate surveys both in military operations and in coming at a true knowledge of the value of your possessions, that we have employed everybody on this service who could be spared and were capable of it. But as the work must ever be imperfect while it is in separate and unconnected plans, we have appointed Captain Rennell, a young man of distinguished merit in this branch, Surveyor-General, and directed him to form one general chart from those already made and such as are now on hand as they can be collected in. This, though attended with great labour, does not prevent his prosecuting his own surveys, the fatigue of which, with the desperate wounds he has lately received in one of them, have already left him but a shattered constitution. This consideration, and his being deprived of every means of advantage while he is thus continually moving up and down a country unexplored by Europeans to the utmost risk of his life, we hope will justify us for increasing his salary to 300 rupees a month, which indeed may be considered as only a just reward for his past services and sufferings." Then followed the ancient policy: "We beg leave to recommend it as a measure well worth your attention, the keeping your Corps of Engineers constantly supplied with young gentlemen properly instructed in that particular branch." Rennell retired in 1776, a broken man, desperately wounded in a riot, and suffering continually from fever. The Journal made one almost tired to read—telling of the man setting off in a boat on the 7th May in order to make a survey of the Ganges River at a time of the year when most Survey Officers should be returning for recess—out through the monsoon as well as the hot weather and cold; never in the hills and never home on leave. There was a piteous letter which he wrote, asking at the end of 13 years' service, that he might be allowed to retire from the Service on a sufficient pension. He was allowed to retire, and he enjoyed that

pension for 54 years! Rennell, the faithful surveyor in the field, and a brilliant scientific geographer in retirement, was the example and the type which had been faithfully followed—the type that had made the Survey of India pre-eminent among the Surveys of the world.

Mr. A. R. Hinks, C.B.E., M.A., F.R.S., Secretary of the Royal Geographical Society, congratulated Colonel Crosthwait upon a very clear and useful statement of the operations of the Survey of India which would be difficult perhaps to find elsewhere and which geographers would particularly welcome when it was published in the Society's *Journal.* The author, being a modest member of that great Service, had not perhaps laid sufficient stress upon two or three points which stood out as the great contributions of the Survey of India to geodesy. India had been for a long time the only part of the British Empire which had made any substantial contribution to the figure of the earth. The contribution from the British Isles had not been a sufficiently large arc to be of much importance, and until the late Sir David Gill measured part of the Great Arc of the 30th meridian in Africa, the contributions of the latitudinal and longitudinal arcs of India had been the only contribution of the Empire to a great problem which interested the whole world. Although the author had made some mention of the investigations of the deviations of gravity, he (the speaker) thought perhaps he had not laid so much stress upon it as that it was evident to the audience that the whole of that fascinating subject was due to the Survey of India in its origin and also in many of its developments. It was quite true that Americans had made great play with the subject since. No one would wish to decry the great merit of the contributions made by Hayford and Bowie, but in the first instance it had been the work of the Survey of India which, with the mathematical assistance of Archdeacon Pratt, had first called attention to the most important fact that the mountains in the Tibetan Plateau did not influence the plumb-line nearly as much as would be expected. Again, it had been that eminent contribution of Sir Sidney Burrard, and, later, the papers of Colonel Crosthwait and other officers, which had thrown so much penetrating light and valuable criticism upon the somewhat artificial assumptions on the subject which had been made by Hayford. Those were eminent contributions of the Survey of India to the stock of great scientific problems of the world, and he thought all present would wish that particular mention should be made of them. They could congratulate Colonel Crosthwait upon having read such an interesting paper, though he had strictly avoided the romance with which Sir Thomas Holdich had treated the subject in his paper read before the Society some years ago. There were two or three picturesque incidents connected with the Survey of India which he would like to mention. There were some well-known tables of logarithms calculated by Shortrede, and in the introduction it was stated that those tables had been calculated "in the sublime solitudes of the Western Ghats." One Royal Engineer had asked him: "Do you know why these tables were calculated in the sublime heights of the Western Ghats? Why was Shortrede there at all?" He had replied that he did not know, and the answer had been: "Because he dropped an 18-inch theodolite off the top of one of those towers." He would like to know if there was any truth in that incident. Then again, there was the romantic episode of the discovery of Mount Everest, which had not happened in the field at all, but in the Survey offices in Calcutta. It must have been a great moment when they had found a mountain, 29 thousand feet high, sticking up in the Survey offices in Calcutta, because no one would judge from looking at the mountain that it was necessarily any higher than some of its surrounding peaks. It was amusing to think how their particularly ardent friend, Sven Hedin, made capital out of the fact that the native name of Mount Everest was found upon the maps of D'Anville, and how he had been at great pains to explain to the public of Sweden that Mount Everest had been discovered by a Jesuit missionary more than 200 years ago, and that its discovery did not lie to the credit of the Protestant English. With regard to policy, the Survey of India was faced with the problem of ten thousand permanently snow-capped peaks lying along the northern frontier. They had to map those peaks, and provide them, as far as possible, with some means of reference. It seemed to him personally that it was the most interesting problem geographically that lay before the Survey, to provide a more interesting method of reference than that which was at present used. The Survey had successfully attached the name of the most eminent of their officers, Sir George Everest, to a mountain, but the trouble it had got into over that little matter had made successive Surveyor-Generals resolve that never again would another officer's name, however eminent, be attached to a mountain. But there the Survey had ten thousand peaks, each of them worthy of a name, and at present no one had thought of a better method of naming them than to call them something like:—"Peak 73 21D," which no one could call convenient in helping one to remember where it was, and which entirely and absolutely forbade any poetical description of the scenery.

Colonel Sir Gerald Lenox-Conyngham, F.R.S., said the scientific work of the Survey of India had had to be interrupted when the war broke out, and, so far as he knew, it had not been since resumed. He was not certain whether some small beginning had not been made during the present winter, but he would like to take the opportunity of saying how important he thought it was that that work should be resumed and carried on. The theory of isostasy owed its origin to the work in India; first of all to Archdeacon Pratt's calculations, and the observations which showed that those calculations could not explain actual facts, and then, in 1901, to Sir Sidney Burrard's Professional Paper No. 5 of the Survey

of India, in which he showed that deflections of the plumb-line were arranged systematically, and that the zones of deflections of a particular character lay parallel to the Himalayas in such a way that it was impossible to doubt that the mountains and the deflections were both due to some common cause. It had been that paper of Sir Sidney Burrard's which had attracted the attention of Mr. Hayford to the subject of mountain attraction and he, utilising the previous work of Dutton and his idea of isostasy, put the theory into a workable form so that it could be actually used for computing attractions. Using his theory, the United States Coast and Geodetic Survey showed that the deflections of the plumb-line in the United States could be accounted for more perfectly than one would have expected. Mr. Hayford had then boldly asserted that the theory of isostasy had been proved and that isostatic compensation did exist. Then the Survey of India took up that theory and, chiefly through Colonel Crosthwait's own exertions, it was applied to the deflections there, and it was found that the calculated deflections did not agree with the observed deflections nearly so well as had been the case in the United States. When a theory was put forward and was tested, if it was found to account perfectly for all known phenomena, then it might be said that the question was settled; the theory was perfect, and there was nothing more to be done; but no one could possibly suppose that the Hayford hypothesis of isostatic compensation was the last word on the subject. It was obviously an approximation to what might be the actual state of things. So what was required was to find those areas in which the computations did not apply, and then examine more carefully what was the state of things there, in the hope of arriving at a more full knowledge of the truth than that first approximation which Hayford's theory gave. As the lecturer had mentioned, the results of computation in India did not bear out the theory of isostasy nearly so well as those in the United States. The residual anomalies were, in the Himalayan area, large. The average difference between a computed and an observed deflection in the Himalayan area was 16 seconds, which was a very large quantity. Therefore it seemed of very great importance for the advancement of science that the research into deflections and gravity phenomena in general should be followed up. There was no place so well adapted for that research as the area in and around the Himalayas, both at the base and on the outer ridges, and also further into the Himalayas themselves. The Himalayan region was the most favourably situated region in the whole world for further research into isostatic compensation.

Sir John O. Miller, K.C.S.I., said the Survey of India was more than a trigonometrical survey, and he would like the lecturer to give a little more information on some points. The scientific work of Survey in India had been from the very beginning admirably done, and it had led in recent years to officers such as Sir Sidney Burrard gaining European reputations. The topographical work of the Survey had not been equally fortunate. A great deal of topographical work had been done 60 or 70 years ago in the time of General Thuillier and others, but since then it had not been pushed on in the same way. There was apparently no pressure then for general maps of the country on a continuous plan; either that was the case, or no person of sufficient eminence came to the front to insist on the topographical work being done. The hopeless condition of the topographical maps had been brought forward very strongly by Colonel Gore when he was Surveyor-General, and India really owed a debt of gratitude to him for having come forward to state that the maps would not do. Colonel Gore put the facts before Lord Curzon, who entered with great zest into the matter. He (Sir John Miller) had been on a Committee which had gone round the country to look into the question, and they had had the great advantage of the advice and assistance of Sir John Farquharson, who was Surveyor-General in this country when the revision of the Ordnance maps was carried through. He desired to pay a tribute to Sir John Farquharson, who had been the first to draw up a definite plan of topography for India. He would like to ask the lecturer how far that plan had been carried out, or how much of India had been mapped, and the maps placed before the public; also whether the general map of India was on the 1-inch or ½-inch scale. There had been great discussions in his time as to whether the general map of India should be on the 1-inch or ½-inch scale, and 1-inch had been decided upon. Sir John Farquharson had raised the question of publishing ½-inch maps. Personally he now thought it would have been wise if ½-inch maps had been adopted for ordinary use and 1-inch maps for special purposes. He expressed the hope that the Government of India would take a liberal view of the necessity for carrying out the programme for the systematic mapping of India. There could not be the slightest doubt that the demand for general maps there would be much greater in the future than it had ever been in the past. No civilised country could preserve its self-respect and be without some general map which the traveller or engineer or soldier could use, and India had not a map of that description at present. He hoped there would not be retrenchment in the future in the Survey Department as had too often been the case in the past. If the Department was given a chance he was sure it would earn as great a reputation in the topographical and reproducing field as it had in the scientific branch. He begged to propose a hearty vote of thanks to Colonel Crosthwait for his interesting and valuable paper.

Sir Lionel M. Jacob, K.C.S.I., in seconding the motion, thought the author had no reason whatever to apologise for his paper in comparison with that which had been read by Sir Thomas Holdich eight years ago. He had himself a very clear and pleasant recollection of Sir Thomas's

delightful paper, but he would like to say that he had enjoyed himself quite as much on the present occasion, and had received perhaps more instruction.

Colonel Sir Charles E. Yate, Bt., C.S.I., C.M.G., M.P., said he was not a surveyor and could not speak on all the scientific matters which had been raised that afternoon. He had, however, been thrown a good deal in the way of Survey officers in India. He had served with Sir Thomas Holdich, Colonel Gore and Colonel Talbot in all their survey operations, right round Afghanistan from Quetta to Kandahar, Kandahar to Herat, Herat to Balleh, Balleh to Kabul, and he had also been at Koh-i-Malik Siah in Seistan, the picture of which had been shewn on the screen, and no one had greater admiration for the work of the Survey of India than he himself had. There was one outstanding feature of the work of the officers of the Royal Engineers who belonged to the Survey of India, namely, how well and how thoroughly they had succeeded in training Indians to be scientific surveyors. These Indians with their plane tables and theodolites, had been able to accommodate themselves to survey work and exploration, and all the hardships attendant thereto, in a remarkable manner. Many of them had done most hazardous service by themselves without any Royal Engineer officer to supervise them, so much so that when he was on the Council of the Royal Geographical Society several of those Indians received special rewards from that Society. He joined with previous speakers in hoping that the present craze for economy, by eliminating British officers from all Departments on the part of the Legislative Councils in India, would not have the result of unduly restricting the further work of the Survey in India.

The motion was carried unanimously.

Colonel Crosthwait, in reply, said that Sir John Miller, having presided over the Survey Committee which had enunciated and arranged in 1905 the Programme of the new system of mapping in India, knew more about the subject than himself. Sir John Miller had asked several questions. One was, to what extent that programme had been carried out? The scale of Survey in the field, as suggested by the Committee to which he had just referred, had been 2 inches to the mile. That had very soon been dropped for financial reasons, and the scale was now 1-inch in the field for British territory, ½-inch for Native States, and ¼-inch for desert areas. That was a very dangerous change to his mind, and should never have been adopted, and was to be deplored from the point of view of providing the country with the best maps, in fact, it was dangerous from every point of view. The military people were crying out for maps on larger scales, but in India the scale was getting smaller and smaller as time went on. In the last report he had seen, of 1,800,000 square miles, about 600,000 had been surveyed and mapped.

The meeting then terminated.

OBITUARY.

George William Taylor.—The Society has lost a Fellow of forty four years' standing by the death of Mr. George William Taylor, which took place on December 27th last.

Mr. Taylor was for fifty nine years connected with the firm of Messrs. Tuck and Company, steam packing manufacturers. For thirty nine years he was managing director and secretary, and for the last five years secretary only. The early days of his connection with this company brought him into close touch with Mr. J. H. Tuck, the American inventor of Tuck's patent packing, which was the first recognised type of engine packing.

Apart from his business, Mr. Taylor's interests were unusually varied and numerous. He was a very keen mason, having attained the rank of 30th degree. He was a practical engineer, electrician, carpenter, plumber, turner (he was a member of the Turners' Company and incidentally a Freeman of the City of London), a painter in oil and water colours, and he was also a musician, being a proficient player of the piano, organ and cello; and during the latter years of his life he was keenly interested in wireless telegraphy.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock:—

February 13.—H. Maxwell-Lefroy, M.A., Professor of Entomology, Imperial College of Science and Technology, "The Preservation of Timber from the Death Watch Beetle." Sir Aston Webb, K.C.V.O., C.B., P.R.A., will preside.

February 20.—Percival James Burgess, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber." Sir Stanley Bois, late Chairman of the Ceylon Chamber of Commerce, will preside.

February 27.—Charles S. Myers, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation." Sir Robert Blair, LL.D., Education Officer, London County Council, will preside.

MARCH 5.—MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

MARCH 12.—ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.) SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., will preside.

MARCH 19.—R. L. ROBINSON, Member of the Forestry Commission, "The Forests and Timber Supply of North America." LORD LOVAT, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., will preside.

MARCH 26.—NEAL GREEN, "The Fishing Industry and its By-Products."

APRIL 2.—SIR LYNDEN MACASSEY, K.B.E., "London Traffic."

APRIL 9.—FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum." PROFESSOR C. VERNON BOYS, F.R.S., will preside.

APRIL 30.—BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "Roads."

MAY 7.—J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation."

Dates to be hereafter announced :—

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock :—

FEBRUARY 15.—SIR RICHARD M. DANE, K.C.I.E., Commissioner, North India Salt Revenue, 1898-1907, and Inspector-General of Excise and Salt for India, 1907-09, "Salt Manufacture in India." THE RT. HON. LORD MESTON, K.C.S.I., LL.D., will preside.

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons at 4.30 o'clock :—

MARCH 4.—THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak." THE RT. HON. LORD BEARSTED will preside.

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

CANTOR LECTURES.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

Syllabus.

LECTURE I.—FEBRUARY 25.—The carbonisation of coal considered as a process for distributing the thermal energy of the coal into therms in the form of gas, tar and coke. Factors which cause wastage of therms in the form of gas and the principles underlying high yields of gaseous therms.

LECTURE II.—MARCH 3.—The inter-relation of therms in the form of gas and tar and the process conditions which affect their distribution. Further principles underlying high yields of gaseous therms. The chemistry and economics of tar cracking.

LECTURE III.—MARCH 10.—The trend of developments in carbonising processes. The de-ashing of coal and other factors tending to increase the value of the therm in the form of coke.

COBB LECTURES.

Monday evenings, at 8 o'clock :—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 11..Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. L. S. Fortescue, "Persian Azerbaijan and the Western Elburz."

Surveyor's Institution, 12, Great George Street, S.W., 8 p.m.

Metals, Institute of (Scottish Section), 39, Elmbank Crescent, Glasgow, 7.30 p.m. Mr. R. Hay, "The Properties of some Non-Ferrous Alloys."

University of London, University College, Gower Street, W.C., 5.15 p.m. Dr. A. S. Parkes, "The Mammalian Sex-Ratio." (Lecture III.).

At King's College, Strand, W.C., 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture II.).

6 p.m. Mon. R. Nathan, "Henri Becque et Georges de Porto-Riche."

5.30 p.m. Dr. R. W. Seton-Watson, "A Survey of Bohemian History." (Lecture II.).

Brewing, Institute of (London Section), at the Engineer's Club, 39, Coventry Street, W., 7.30 p.m. Messrs. H. L. Hind and S. Myer, "The Value of Hops from the Technical and Economic Standpoints."

TUESDAY, FEBRUARY 12..Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. C. H. McCarthy-Jones, "Electricity applied to the Winning of Crude Petroleum with special reference to the Yenangyoung Field, Burma."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Hon. H. P. Colebatch, "Western Australia."

Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Mr. G. Brown, "Pictures of Burma."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. J. Barcroft, "The Respiratory Pigments in Animal Life." (Lecture I.).

Photographic Society, 35, Russell Square, W.C., 7 p.m. Dr. C. E. K. Mees, "Research."

Mechanical Engineers, Institution of (Glasgow Branch), Royal Technical College, Glasgow, 7.30 p.m. Prof. S. P. Smith, "The Electrification of Railways in Foreign Countries."

Welding Engineers, Institution of, at the Institute of Marine Engineers, 85, The Minories, Tower Hill, E., 7 p.m. Mr. J. R. Booer, "Some Chemical Aspects of Welding."

Metals, Institute of (Local Branch), Chamber of Commerce, New Street, Birmingham, 7 p.m. Discussion on "Waste Products and Losses in the Non-Ferrous Metal Industry."

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. J. H. Helweg, "Modern Danish Lyrics, 1870-1920." (Lecture II.).

5.30 p.m. Mr. N. H. Baynes, "The Roman Empire and its Invaders." (Lecture II.).

8 p.m. Miss E. J. Davis, "The City Churches and their Endowments." (Lecture II.).

5.30 p.m. Sir Bernard Pares, "Russia before Peter the Great to 1861." (Lecture IV.).

5.30 p.m. Dr. H. W. Carr, "The Transition to the Relativist Conception of Nature." (Lecture II.).

5 p.m. Prof. F. C. Burkitt, "Christian Beginnings." (Lecture II.).

WEDNESDAY, FEBRUARY 13..British Decorators, Institute of, Sheffield, 7.30 p.m. Mr. Z. Carr, "A Few Impressions of Colour and Decoration by an Architect."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m.

Metals, Institute of (Local Section), Armstrong College, Newcastle-on-Tyne, 7.30 p.m. Mr. A. Logan, "Propeller Brass."

Mechanical Engineers, Institution of (Local Branch), Council Chamber, Birmingham, 7.30 p.m. Discussion on "The Relative Advantages of Transport by Road and Rail, with special reference to the Future."

University College, Gower Street, W.C., 5.30 p.m. Prof. Geyl, "English Diplomacy in Holland in the XVIIIth Century." (Lecture I). 5.30 p.m. Mr. I. C. Grøntahl, "Contemporary Norwegian Literature." (Lecture II.).

5.30 p.m. Mr. S. Gibson, "Oxford Libraries."

6 p.m. Prof. K. Pearson, "The Current Work of the Biometric and Eugenics Laboratories." (Lecture I.).

THURSDAY, FEBRUARY 14..Pottery and Glass Trades' Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.45 p.m. Mr. L. King, "Decoration of Table and Fancy Glass Ware."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. Sir W. Bragg, "Crystalline Structure of Organic Substances." (Lecture II.).

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W., 5 p.m. Mr. L. S. Fortescue, "The Caspian Provinces of Persia."

Historical Society, 22, Russell Square, W.C., 5 p.m. Annual Meeting. Address by President Dr. the Hon. J. W. Fortescue.

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. (Joint meeting with the Physical Society). Discussion on Loud-Speakers for Wireless and other Purposes."

Economics and Political Sciences, London School of, Houghton Street, Aldwych, W.C., 5 p.m. Sir H. L. Smith, "The Economic Laws of Art Production." (Lecture V.).

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Metals, Institute of, at the Institute of Marine Engineers, 85, Minories, E., 8 p.m. Mr. W. B. Clarke, "Metals for Lamp Manufacture."

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. I. Björkhagen, "Modern Swedish Prose Authors." (Lecture II.).

5.15 p.m. Prof. J. E. G. de Montmorency, "Comparative Customary Law of Europe and Asia." (Lecture IV.).

8 p.m. Prof. H. E. Butler, "Roman Private Life." (Lecture IV,).

At King's College, Strand, W.C., 5,30 p.m. Dr. E. W. Scripture, "What the Voice looks like." (Lecture I.).

5.30 p.m. Prince D. S. Mucky, "The History of Russian Literature. (Lecture IV.).

At the London School of Medicine for Women, Hunter Street, W.C., 5 p.m. Prof. W. C. Cullis, "Respiratory Exchanges." (Lecture IV.).

FRIDAY, FEBRUARY 15..Royal Institution, Albemarle Street, W., 9 p.m. Dr. J. H. Jeans, "The Origin of the Solar System."

Medical Officers of Health, Society of, 1, Upper Montague Street, W.C., 5 p.m. Prof. G. Dreyer, "Some Principles underlying Bacteriological Immunity and Vaccine Therapy."

Metals, Institute of (Local Section), at the Albany Hotel, Fargate, Sheffield, 7.45 p.m. Joint Meeting with Institute of British Foundrymen.

(Local Section), at University College, Singleton Park, Swansea, 7.15 p.m. Prof. C. H. Desch, "Fatigue and the Elastic Limit."

Mechanical Engineers, Institution of, Storey's Gate, S.W., 7 p.m. (Informal Meeting.) Mr. A. E. L. Chorlton, "The Possibility of Internal Combustion Locomotives."

University of London, University College, Gower Street, W.C., 5 p.m. Prof. J. Robertson, "The Influence of Improved Town Planning and Housing in Public Health." (Lecture III.).

At King's College, Strand, W.C., 5.30 p.m. Dr. H. Lamb, "The Internal Constitution of the Earth." (Lecture I.).

5.30 p.m. Prof. R. W. Seton-Watson, "The Rise of Nationality in the Balkans." (Lecture IV.).

SATURDAY, FEBRUARY 16..Royal Institution, Albemarle Street, W., 3 p.m. Dr. R. S. Rait, "The Last Years of the Scottish Parliament." (Lecture II.).

London County Council, Horniman Museum, Forest Hill, S.E., 3.30 p.m. Miss C. A. Raisin, "Glaciers and Ice Work of the Past."

# Journal of the Royal Society of Arts.

No. 3,717 VOL. LXXII.

FRIDAY, FEBRUARY 15, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.2.

FUND FOR PURCHASING AND RENOVATING THE SOCIETY'S HOUSE.

Nine lists of subscriptions to this fund have been published from time to time in the *Journal*;* and a desire has been expressed by a number of Fellows that a complete list giving all the contributions up to the present date should be issued.

It will be seen that the amount received is now £42,803 17s. 5d. The cost of the freehold and legal expenses was £42,560, while the renovations, architect's fees, and furniture for the library accounted for a further £8,450. It is, therefore, still necessary to raise over £8,000, and the Council are exceedingly anxious to see this reduced as rapidly as possible. They desire to take this opportunity of thanking those Fellows who have already subscribed to the Fund—many of them with great generosity; and they earnestly appeal to those whose names have not yet appeared on the subscription lists to assist them in paying off the debt.

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NOTICES.

NEXT WEEK.

Wednesday, February 20th, at 8 p.m. (Ordinary Meeting.) Percival James Burgess, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber." Sir Stanley Bois, President, Ceylon Association in London, will preside.

Further particulars of the Society's Meetings will be found at the end of this number.

INDIAN SECTION.

A meeting of the Indian Section Committee was held on Monday, February 4th. Present: Sir Edward A. Gait, K.C.S.I., C.I.E., Ph.D., in the chair; Sir George S. Barnes, K.C.B., K.C.S.I., Sir Thomas J. Bennett, C.I.E., Mr. Laurence Currie, M.A., J.P., Sir William Duke, G.C.I.E., K.C.S.I., Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S., Major-General Beresford Lovett, C.B., C.S.I., Major H. Blake Taylor, C.B.E., and Colonel Sir Charles E. Yate, Bt., C.S.I., C.M.G., M.P., with Mr. S. Digby, C.I.E., Secretary of the Indian and Dominions and Colonies Sections.

NINTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 6th, 1924; LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:

Elston, Frederic, London.
Mant, Sir Reginald Arthur, K.C.I.E., C.S.I., London.
Smith, Frederick Richard, Hampden-in-Arden.
Young, Brig.-General Henry Alfred, C.I.E., C.B.E., Exmouth.

The following candidates were duly elected Fellows of the Society:—

Bailey, Charles Henry, Chepstow, Mon.
Chamberlain, Clark W., A.B., Ph.D., Granville, Ohio, U.S.A.
Charawanamuttu, V. Edward, A.C.P., Kotahena, Colombo, Ceylon.
Cutner, Mrs. Frances Maud Mayfield, London.
Davis, Cecil, London.
Edwards, Kenneth C., Chester.
Evans, Samuel, Johannesburg, S. Africa.
Fuge, Captain William Valentine Greatraks, Cairo, Egypt.
Graham, Archibald, Oxford.
Gray, Arthur Wellington, Ph.D., Delaware, U.S.A.
Gray, Major-General William du Gard, C.B., J.P., Dulverton, Somerset.
Hooker, Dr. Samuel Cox, Brooklyn, New York, U.S.A.
Jones, Arthur Cadbury, London.
Khadir Meera Sahib, S.K.I., Salem, India.
Kimbell, Alfred Edward, London.
Klein, Millard A., Ph.D., Stockton, California, U.S.A.
McGregor, Dr. Robert, Michigan, U.S.A.
McLaughlin, Professor George D., Cincinnati, Ohio, U.S.A.
Matthews, William Cooper, Stafford.
Morley, Henry Thomas, Reading.
Morrison, Francis, B.Sc., London.
Morse, Charles, K.C., D.C.L., Ottawa, Canada.
Plummer, Professor Henry Stanley, M.D., Minnesota, U.S.A.
Pullen, Hugh C. G., Rio de Janeiro, S. America.
Ramsay, Dr. William Miller, Nausori, Fiji.
Rose, Joseph William, Bath.
Rose, Mrs. Ruth Starr, Maryland, U.S.A.
Rosenberg, Charles Conrad Constantine, M.D., Oregon, U.S.A.
Sahni, D. C., M.A., Patiala, India.
Spencer, Walter T., London.
Tatham, Francis John, London.
Townson, Rev. C. H., M.A., Warminster.
Ward, Sir Thomas Robert John, C.I.E., M.V.O., London.

A paper on "The Earthquake and the Work of Reconstruction in Japan" was read by MR. IYEMASA TOKUGAWA, First Secretary to the Japanese Embassy.

The paper, which was illustrated by cinematograph films, will be published in a subsequent number of the *Journal*.

COMPETITION OF INDUSTRIAL DESIGNS.

Particulars of the Competition of Industrial Designs to be held at the Victoria and Albert Museum in June, 1924, can now be obtained on application to the Secretary, Royal Society of Arts. Over £1,000 will be offered in Travelling Scholarships and Money Prizes in the various sections, and the Society's Diploma will be conferred on any candidate whose work reaches a very high standard of artistic ability and shows practical knowledge of the materials and processes of his trade.

PROCEEDINGS OF THE SOCIETY.

SEVENTH ORDINARY MEETING.

WEDNESDAY, JANUARY 23RD, 1924.

MR. G. E. BROWN, F.I.C., Editor of the *British Journal of Photography*, in the Chair.

THE CHAIRMAN said that it was hardly necessary for him to introduce Mr. Albert Smith, because a great many people must be familiar with his invention of the Kinemacolor process of colour cinematography, which was first demonstrated in the Society's Rooms 14 or 15 years ago. The Kinemacolor process was the first commercially successful process of colour cinematography. It had its limitations, but it delighted a large section of the public for a good many years. That evening Mr. Smith was about to show a further development of colour cinematography which he had worked out. He did not think that Mr. Smith even

yet regarded this as the final process by any means, but he would be able to show the kind of results he had secured up to now.

The paper read was :—

CINEMATOGRAPHY IN NATURAL COLOURS.

Further Developments.

By G. Albert Smith.

In December, 1908, it was my privilege to address this Society on the subject of colour photography, and to exhibit a series of cinematograph pictures—the first of such pictures taken in natural colours. On that occasion I went somewhat fully into the theories of light and colour involved in such questions, and I also described the main principles of the cinematograph.

On the present occasion it is unnecessary to go over all that ground again (especially as I have a long programme of pictures), because what I said was fully recorded in the *Journal* of the Society (No. 2925, Vol. LVII., Dec. 11th, 1908); and also because the fundamentals of colour photography, and of the cinematograph, are now more generally understood. For instance, I think everyone now knows that the explanation of the cinematograph is simply that successive snap-shots are taken on a moving band of film at the rate of 16 per second, and that these snapshots are then exhibited one after the other at such a speed (again 16 per second) that by what is known as persistence of vision the successive pictures combine on the retina and give us the illusion of movement. If the pictures are taken at a slower rate of speed, we get the impression of jerky and hurried movements. If they are taken at a higher rate of speed—say 40 per second—we get an impression of slow and dragged-out movement.

Turning to *Colour*, it is well-known that the superimposition on paper of three correctly chosen colour records will give a picture approximating to the colours of nature; and the same results can be attained by the superimposition of three beams of coloured light passing through lantern slides to a white screen in a darkened room. The "three-colour theory" first promulgated by Thomas Young, early in the last century familiarised us with these facts, and all processes of colour photography and colour printing are based upon it.

In my last paper and demonstration in this room, I discussed the application of this "three-colour theory" to the art of the cinematograph, and described careful and thorough tests made as far back as 1902, which resulted at that date in failure. The failure was mainly due to the fact that we employed *three lenses*, placed as closely together as possible, but which necessarily took three pictures very slightly *differing* from one another. These slight differences became aggressive when the pictures were superimposed, for they produced coloured margins where overlapping occurred.

It was next found that it was practicable to reduce the three colours to *two only*, and this fortunate fact greatly simplified the problem, as we shall see. The "three-colour theory" divides the spectrum into three parts, the red, the green and the blue-violet. In the case of prints upon paper to be *viewed by daylight* the three separate impressions are all necessary if the resulting picture is to appear at all true to nature. But in the case of transparencies to be viewed by projection with some artificial light, the spectrum can be divided into two with very pleasing results. This is probably because a deficiency of colour at the violet end of the spectrum is not noticed in the absence of daylight.

But when the attempt was made to superimpose even this reduced number of records cinematographically, accurate registration still proved impossible—due again to the pictures slightly differing from each other, because of the use of two lenses in taking.

The next step was to take the pictures through one lens only, so as to ensure the same point of view for each, to take the two pictures (a red sensation and a blue-green sensation) in the time usually occupied in taking one picture, and to do this 16 times per second, making 32 pictures per second in alternate colour values.

The pictures were then projected on the screen *successively* at *twice the usual speed*, so that by "persistence of vision" the two-colour records would blend on the retina. This scheme worked very well up to a point. It became known as Kinemacolor. The system was officially used to record the glowing scenes of the Indian Delhi Durbar of King George and Queen Mary, in 1911-12, and exhibitions were given with considerable success in the principal cities of the world.

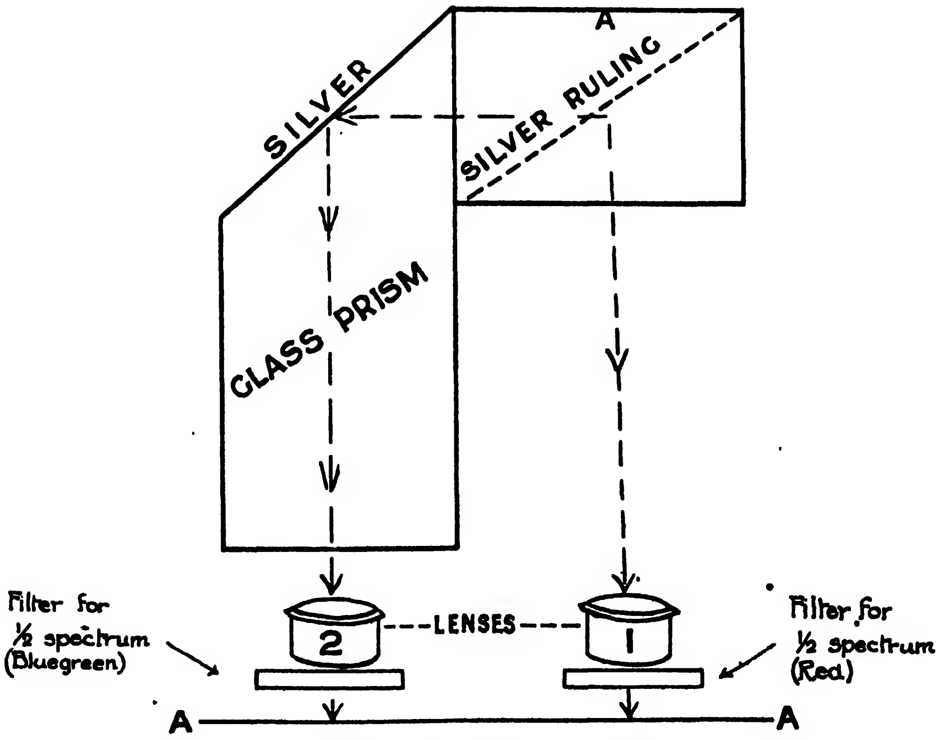
The Kinemacolor system, successful and pleasing though it was when well managed, had one or two practical drawbacks. One was that the film had to run in the projecting machine at twice the ordinary speed at least, so as to project 32 or more pictures per second instead of the 16 per second required for ordinary black and white pictures. The other and more serious drawback was that with *rapidly moving things* it was impossible to take the required *two* pictures (one in each colour) before the said subject moved, and this displacement of image caused bad "colour fringing" when projected on the screen. A lady kissing her hand from the casement window was apt to display a stream of red and green hands, an effect which rather destroyed the colour charm residing in the other portions of the picture where the action was less energetic.

This "fringing" defect naturally led to the conclusion that it is *absolutely necessary* to take two identical snapshots of everything *before it has time to move*, no matter what its speed. Two lenses are no good, because no matter how closely they are mounted together, they cannot take identical pictures. So what we really want is *a single lens that takes two pictures at once !*

A group of English experimenters,* assisted by skilled English opticians, succeeded after many trials, in constructing an optical taking-system which secured this desirable result; and in due time pictures were taken by it and christened Cinechrome. Of course, in the evolution of the process they tried several schemes suggested by one and another, and as experience was gained gradually eliminated the faulty ones. The present Cinechrome process of taking *two identical snapshots* at once, successfully abolished the old fault of "fringing" due to phases of movement being missing; and it is the Cinechrome process of colour cinematography which I am going to demonstrate to you to-night.

But you might first like to see a simple diagram explaining the arrangement by which the two identical snapshots are secured.

* Messrs. Cinechrome, Ltd., 8 and 9, Long Acre, W.C.



AA: Cinematograph Film

The picture to be taken is on its way to lens 1, but first has to pass through the prisms A. These are cemented together with a silver ruling between them. Only half the rays of light can pass through the spaces of the ruling to lens 1, whence they carry their image through the red colour filter to the cinematograph film AA which is nearly double the usual width. The other half of the rays in the prisms marked A are stopped by the silver lines, and reflected to the silver sheet, as shown by the dotted line. From this silver sheet they are again reflected at 45° down the path of the dotted line to lens 2, whence the second image passes through a blue-green filter and deposits itself upon the sensitive cinematograph film by the side of the other one. One exposure will thus give us two pictures side-by-side, and identical in every respect. When the film moves through the camera by the ordinary cinematograph method, taking snapshots at the rate of 16 per second, we secure a double row of snapshots instead of the usual single row, and each row is a colour-value record derived from half of the spectrum.

To view these pictures in the full colours of the spectrum, all we have to do is to make a print from the negative and run it through a cinematograph projecting machine. From time to time, many complicated and expensive optical systems have been designed and tested, but to-day Messrs. Cinechrome, Ltd., use none of these. The present machine does not differ from the machines in use at the regular Cinemas—in fact, it can be used for ordinary black and white projection in any theatre, but, by a simple adjustment, it can take a double-width film when required, and by means of an extra lens project the two rows of pictures at once. By a few turns of a milled head the two lenses can be made to converge their beams so that the side-by-side pictures become superimposed on the screen. Each lens is provided with a colour filter of glass, somewhat similar to the filters used in the camera, so that when superimposed the two halves of the spectrum are brought together on the sheet. If presently you will glance at the machine when working, you will see that a beam of red light emerges from one lens, and a beam of bluish green light from the other. The two beams unite just before reaching the screen, and on its surface produce the re-composed scene, because the varying densities of the black and white cinematograph film intercept the beams of colour in varying proportions determined by the nature of the scene originally photographed.

The pictures to be shown to you to-night, all taken by the process described, are mainly of the tour of H.R.H. the Prince of Wales recently through India and Burma. I had the privilege of being attached to H.R.H.'s party as Official Cinematographer in Colour, and by the courtesy of the Indian Government had exclusive opportunities of taking pictures of every event of the long tour. The negatives were all developed in India under very primitive conditions—in a bath room, in fact, attached to the Connaught Hotel, at Poona, where members of the technical staff of the Cinechrome Company worked on them at night, which was the only time the water could be kept cool enough, even with ice.

You may possibly have the impression that the majority of these Indian pictures are lacking in *green*; hedges, trees and grass are sometimes inclined to be sandy. The explanation is that during the period of our visit, the winter, everything was very dry; I only recall one fall of rain during the 4½ months of my journeyings in India. I am informed that during the monsoon, or rainy period, the greens are as fresh and vivid as one can wish, but we were there during the dry period. In case you should imagine that the lack of bright greens is due to some fault in the process used, I shall start with a few miscellaneous pictures taken at home, when you will at once see that the bright greens, which we are accustomed to see in nature, are satisfactorily reproduced.

[At the close of the paper several reels of film were exhibited, chiefly illustrating the tour of H.R.H. the Prince of Wales in India. On this subject alone 3,500 ft. were projected. In addition Mr. Smith showed a number of miscellaneous subjects, chiefly in order to illustrate the fact, which was not so demonstrable in the Indian pictures, that the process could reproduce adequately the greens in Nature.]

DISCUSSION.

THE CHAIRMAN proposed a vote of thanks to Mr. Smith for his most admirable and convincing demonstration. He thought it was obvious

to everyone that cinematography in colour was now practicable, at any rate so far as technical conditions were concerned. Whether this was a process which would satisfy the commercial world of cinematography was a matter which did not concern them at that meeting. He could only say that, having seen, he thought, a demonstration of every process of colour photography which had been offered to the public, he had never seen results which came near to those which Mr. Smith had exhibited that evening. It seemed incredible that these results should have been obtained by means of combination on the screen of two colours only. Many of those present would remember the results which in still photography were obtained years ago by Mr. F. E. Ives, who was a great pioneer in these processes. Mr. Ives employed three colours—red, green, and blue-violet projections. Mr. Ives' colour photographs, both on the screen and also in his viewing instruments, were very beautiful: they were probably as beautiful examples of colour photography as had been made up to the present, but when one looked at some of the film records which Mr. Smith had shown that evening, and particularly some of the Indian landscapes, one could hardly believe that they were not made by the much more complicated three-colour method which Mr. Ives used more than 20 years ago. But he believed that Mr. Smith would agree with him that the problems he had to surmount had not been chiefly photographic problems, but mechanical and optical ones, the optical problem being to make the two images come exactly into register, and the mechanical problem that of showing each of the two pictures at exactly the same instant.

Lord Askwith, K.C.B., K.C., D.C.L. (Chairman of the Council), seconded the vote of thanks with the greatest pleasure. If Mr. Albert Smith had done nothing else, he had at least brought into the minds of the audience that evening some warmth and some colour on a very grey, if not black, day in the City of London. He had also shown the wonderful scenes in India which accompanied the Prince of Wales's tour. Looking at those photographs some people might think that India was quite a small country after all, because Mr. Smith had managed to show so much of it in one evening. He had darted from Rangoon to Mysore, then to Hyderabad and to Gwalior, Nepal, Lahore, Peshawar and back to the starting point at Bombay. The costumes, the vivid colour, and the interesting people whom he had shown would, however, bring back to the mind something of the vast extent of India. He was of opinion that perhaps the most interesting picture Mr. Smith had shown was that of the elephant procession at Gwalior, and he wondered whether the elephants recognised each other in their extraordinary dress. Mr. Smith appeared to be rather sorry for himself because he went up that steep hill at Gwalior on the back of an elephant, but the speaker could tell him that if he had walked up the hill on a hot day he would have found it much worse. It was many years ago since he went to Gwalior, but the heat of the day and the climb up that hill would never be forgotten by him for the rest of his life. Mr. Smith had also done a great work in bringing back these photographs, because they placed on record, probably for all time, one of the most interesting journeys of the Prince during recent years. Conditions in India as the decades went by might change rapidly, and therefore the record was all the more valuable. The colour photography had an obvious advantage to which black and white photography could never pretend. It brought before them the marvellous colour of the East, especially the reds and the golds, and it also illustrated the sort of atmosphere and movement which there existed. He seconded the vote of thanks with much pleasure.

The vote of thanks was accorded unanimously.

Mr. Albert Smith thanked the Chairman and Lord Askwith for the complimentary way in which they had proposed and seconded the vote of thanks. The audience had already paid him the greatest compliment—that of complete attention—and this he appreciated most warmly. The Chairman had drawn attention to the fact that in the completion and carrying through of this process great mechanical difficulties had to be surmounted. The credit for that mechanical work ought to go to Messrs. Cinechrome Ltd., who had been engaged for such a long time in perfecting this process. It was to the clever engineers of that Company that the greatest part of the credit belonged. He himself had done his best to contribute what little knowledge and help he could so far as the colour part of the work was concerned, but the technical and mechanical part of it was beyond his powers. Messrs. Cinechrome Ltd., did not feel that they had reached finality in this respect, but they had reached a point at which the process was workable. The process had not been offered to anyone else in the commercial sense, and these films had not been exhibited except to bodies like the Royal Society of Arts and to officials of the India Office and elsewhere. There might still be a good deal of work to be done before the process could go before the public. Once more he thanked them for the kind and appreciative manner in which they had followed the paper and demonstration.

The proceedings then terminated.

OBITUARY.

FRANCIS JOHN WARING, C.M.G., M.Inst.C.E.—Mr. Francis John Waring died at his residence at Ealing on February 6th, at the age of 80. After being educated at King's College School, he proceeded to India, where he was engaged on the Indus Valley railway survey, and subsequently on the construction of the Delhi Railway. In 1872 he went to Brazil, on his appointment to the Sao Francisco and Tocantius railway survey, and three years later he entered the service of the Ceylon Government as district engineer, subsequently becoming chief resident engineer. He was responsible for the construction of various mountain railways, and made a trigonometrical survey of Adam's Bridge to connect India and Ceylon.

In 1896 Mr. Waring returned to this country and set up in practice in Westminster. He held a large number of appointments, being consulting and inspecting engineer to the Crown Agents for the Colonies for the Government railways in Ceylon, the Malay Straits, Trinidad, Nyasaland, and for the Demerara, British North Borneo, and Central Africa Railways. He was awarded a Telford premium and a Crampton prize for papers read before the Institution of Civil Engineers.

Mr. Waring was elected a member of the Royal Society of Arts in 1892, and he spoke in discussions and contributed letters to the *Journal* from time to time.

NOTES ON BOOKS.

MECHANICAL ROAD TRANSPORT. By C. G. Conradi. London: Macdonald and Evans. 21s. net.

This handsome volume of 394 demy octavo pages, with its plates and numerous engravings in the text, is an exhaustive, lucidly written and well illustrated monograph on commercial traffic on the highways—i.e. both persons and goods, but excluding the private pleasure car.

Direct motor traffic from source to destination, without change or delay at terminals—and often without packing, seems to offer a fascinating prospect for long distance delivery and for mitigating congestion on the railways. Indeed, Mr. Conradi foreshadows the time when that progress in legislation which he details (p. 10), may culminate in the allowing of motor-trains on our highways. He points out that properly designed road-trains, in which both the driving and the load are distributed over the whole length of the train, may carry large tonnage with a minimum of road-wear; reference being made to demonstrations by Renard and to the more recent trials by Durtnall.

In his comprehensive chapter on Fuels, Mr. Conradi touches on the question of gaseous fuel for road traffic, and despite the theoretical economy of producer gas and statements regarding a commercial "producer" vehicle having been run satisfactorily for two years, the author considers it to be extremely problematical whether such a system can ever be a commercial success; the gas "producer" being so inherently slow to a sudden call for more power, to say nothing of tendency towards corrosion.

Gas supplied from an outside source and either bagged, or under high compression comes into quite another category and considerable space and many illustrations show the various outcomes of the pioneer work done in this direction by Messrs. Barton of Beeston. Perhaps the most promising aspect of gas fuel is the use of grouped compression cylinders, and automatic release into a low-pressure flexible holder, as depicted by Fig. 12, p. 39.

In a thorough and masterly manner, Mr. Conradi guides his readers through the long range of parts from the magneto to the automatic diary or work recorder (Fig. 180, pp. 257-8); from the Bantam truck for 10 cwts. to 6-wheel or 8-wheel systems of which a portion may be disconnected (pp. 202-204, Figs. 121, 122, 124, 125, 132); laws and regulations, from the Carriers Act of 1830 to the scale of taxation under the Act of 1920; working costs, from interest on capital to lubricating oil and waste; and finally books or writings from Stuart's Anecdotes of steam engines to O'Neill on Colloidal Fuel.

The publishers and Mr. Conradi are to be congratulated on the present volume, and as road transport takes new aspects we may expect new editions.

THE CO-OPERATIVE MOVEMENT IN JAPAN. By Kioshi Ogata, with a Preface by Sidney Webb. London: P. S. King and Son. 12s. 6d.

In several respects this work is remarkable, as it embodies elements of research and tabulation which bear pertinently on vital questions of world-wide importance.

Even if Dr. Ogata's study of the recent activities of co-operators in Japan had been a bare history of the movement, it would have possessed notable value as a contribution to social history; but he has supplemented the unbroken and sequent story by abundant footnotes which give particulars as to co-operative activities in other countries, views of authorities, historical or legal items, cross references to the text, and such numerous details as make the work one of altogether exceptional value to those who are interested in social thought or progress.

The author makes it clear that the numerous co-operative units now existing in Japan are generally, or perhaps entirely, free from or independent of Socialistic tendency, and are spontaneous efforts of the industrial classes to associate themselves for mutual advantage. The Japanese Government, which is not favourable to Socialistic doctrine, rather assists the co-operators, by such aid as can be afforded without material risk or loss to the public funds; this aid being, in the main, analogous to the facilities given to the various building societies by the British Government from about 1846 forward; and there is considerable analogy between the local credit banks of Japan, which are the financial bases of the

co-operative societies, and the Starr-Bowkett Building Societies, of which it is said there were at one time more than 1000 in Great Britain (pp. 18-22).

We may probably assume the co-operators of our Building Society period, as also the Rochdale pioneers, and those who laid the foundations of the Civil Service Supply Association, to have acted quite independently of any political motive or of any notion of promoting Socialistic doctrines; and the generally favourable attitude of the British Governments, like that of the present Japanese Government, may be attributed to a wish to minimise Socialistic propagandism, and to weaken any arguments for revolutionary socialism. Thus, the account of spontaneous Japanese co-operation as told in the work before us is admirably illustrative of co-operation as something apart, as a sect, or in its separate and independent condition; that is to say, in strong contrast with the so-called co-operative movements engineered in France by Godin and by Fourier, also in Great Britain by Robert Owen. These men were ardent socialists, and endeavoured to promote Socialism by something called co-operation, but it was little more than a blind obedience of the workers to the dicta of the well meaning autocrat who supplied funds and imagined schemes of social reconstruction.

Professor Ogata's scholarly method of studying actual events, touching on historical parallels with a light hand, and showing considerable diffidence or caution in arriving at conclusions, gives us the kind of treatise which is now required.

A good example of his mode of study is to be found (pp. 182-187), where he treats of the obstacles to co-operative progress in Japan, and considers causes of failure as exemplified by some 4,000 societies which have fallen out by the way during a certain period.

This study of failures when considered in contrast with the much greater record of successes, as given in pp. 174-181, suggests a stage in social fluidity: a stage at which there is a very distinct tendency towards the survival of the better forms and the extinction of those subject to degenerative influences; "disloyalty," "apathy," "discord," "inefficiency of the elected officials" (pp. 185-186).

In his story of healthy growth under this natural or automatic process of weeding out the unfit, Professor Ogata's story seems to lead us towards a better understanding of the ancient concept of the social group, State, or administrative-unit as an organism. Birth, growth, death and susceptibility to either melioration or pejoration are characteristics common to all organisms, and if the above mentioned parallel is to be made to bear on applied economics, some method must be devised to give a self-extinguishing tendency to inefficient public departments, comparable to that self extinguishing tendency which now looms over inefficient private businesses, associations, or joint stock companies.

The application of the organism notion to the high senate of the ultimate or ideal state of the Marxians is more difficult, as, should such a state be possible, and actually realised, every condition like competitive stress and purgation must be at an end.

On the side of confident prediction as to the possibility and desirability of the ideal Marxian state, the student may well read the "Fabian Essays in Socialism" (Walter Scott). The "Democracy and Reaction" of L. T. Hobhouse (T. Fisher Unwin), suggests a doubt whether even a near approach to such an ideal state is possible, and that something comparable to a period of diminishing, disappearing or reversed returns may step in at an early period, and the work now under notice gives concrete instances of great value, as tending to cast indirect light on these problems.

The South American Handbook, 1924. London: South American Publications, Ltd. 7*s*. 6*d*. net.

This handbook, excellently written and excellently planned, is packed so full of information that in writing a short notice of it one hardly knows what to select for comment. Perhaps the most interesting pages are those which describe the journey across the Andes. The railroad climbs with wonderfully even gradients from Mollendo on the coast of Peru to the enormous height of 14,688 feet, which it attains at a distance of 210 miles from the sea. The scenery is amongst the grandest in the world, and this is not the only charm of the journey. Cuzco, which witnessed the rise and fall of the Inca Empire is a city of intense interest to the historian and archæologist, as well as to the sculptor and painter. Its fortress of Sachsahuaman ranks among the wonders of the world, and it is uncertain whether it dates from Incaic or pre-Incaic times. Almost every street in the town has remains of Incaic or pre-Incaic stonework, the perfection of which fills the architect of to-day with admiration and amazement.

"It is curious," says the Handbook, "after travelling for several days on the Southern Railway in the high altitudes of the Andes, to alight on the shores of Lake Titicaca and see at the pier a vessel which has the appearance and almost the size of an ocean liner." The surface of the lake is some 12,500 feet above sea level, and it was no mean engineering feat to bring up to this height by railway the various parts of the S.S. "Inca" and reassemble them on the lake. The "Inca" is 128 ft. long, and has a 46 ft. beam, with quarters for 86 first-class passengers, and is rated for 1,000 tons of cargo. Her predecessor, the "Yapura," which has been navigating the lake since 1861, was brought all the way from the sea on backs of Indians and mules.

Lake Titicaca is not only one of the largest, but also one of the most beautiful of inland waters. Some of the mountain peaks rise nearly two miles above the surface of the water, and the beauty of the view just before sunrise, when seventy-five miles of perpetual snow emerge from the darkness, is said to be unsurpassed.

One Hundred Years' History of the Chinese in Singapore. By Song Ong Siang, M.A., LL.M. (Cantab.). London: John Murray.

Singapore was founded as a settlement by Sir Stamford Raffles, on February 6th, 1819. At that time the population of the island amounted to about 150 fishermen and pirates living in a few miserable huts: about thirty of these were Chinese, and the rest Malays. In little more than a year the population had risen to ten or twelve thousand souls, principally Chinese. Thanks to its geographical situation, which has made it extremely convenient as a trade depot, this increase has been steadily maintained until at the last census in 1921, the population was returned at 350,355, of whom some 70 per cent. were Chinese; while the harbour, in the extent of its shipping, is one of the greatest in the world, the number of vessels entered and cleared in 1922, exclusive of native craft, being 11,738, with a tonnage of 18,280,279.

The present work is described by the author as "a chronological record of the contribution by the Chinese community to the development, progress and prosperity of Singapore; of events and incidents concerning the whole or sections of that community; and of the lives, pursuits and public services of individual members thereof from the foundation of Singaporion, 6th February, 1819, to its centenary on the 6th February, 1919." The record has been divided into ten decades, and Mr. Song Ong Siang has certainly spared no pains in investigating the materials at his disposal; indeed, if we have a fault to find with the work it is that there is so much detail that it is difficult to see the wood for the leaves. This, however, is a fault on the right side, and one that it is difficult to avoid in a book of this description. The author has had to investigate the careers of a great many of his fellow-countrymen, and he has been fortunate in finding photographs of many of them, which certainly add a great interest to the volume.

As one would expect when one considers their number, the Chinese of Singapore have been of all sorts, good, bad and indifferent. Amongst those first mentioned in the book was one who was hanged for murder at the first Criminal Sessions held in 1828, and from time to time great trouble was given to the authorities by the lawless secret societies which won for themselves an unenviable reputation, and flourished on vice and crime. On the other hand a large proportion of the Chinese were hard-working folk, and it was largely owing to their peaceful and industrious habits that the trade of Singapore developed as it did. Nor can one help being struck by the large amount of public spirit among the leaders of the Chinese community of Singapore; the generosity of the merchant princes is manifested over and over again, and their readiness to contribute to charitable and educational institutions is most admirable.

Mr. Song Ong Siang has carried out a difficult and laborious task with great success, and he leaves us with a very pleasant impression of his fellow-countrymen in Singapore.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock:—

February 20.—Percival James Burgess, M.A., F.C.S., Chairman, Rubber Growers' Association, "New Uses for Rubber." Sir Stanley Bois, late Chairman of the Ceylon Chamber of Commerce, will preside.

February 27.—Charles S. Myers, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation." Sir Robert Blair, LL.D., Education Officer, London County Council, will preside.

March 5.—Major-General Sir Fabian Ware, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

March 12.—Alan A. Campbell Swinton, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.) Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., will preside.

March 19.—R. L. Robinson, Member of the Forestry Commission, "The Forests and Timber Supply of North America." Lord Lovat, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., will preside.

March 26.—Neal Green, "The Fishing Industry and its By-Products."

April 2.—Sir Lynden Macassey, K.B.E., "London Traffic."

April 9.—Frank Hope-Jones, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum." Professor C. Vernon Boys, F.R.S., will preside.

April 30.—Brigadier-General Sir Henry Maybury, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "Roads."

May 7.—J. Robinson, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation."

MAY 14.—

MAY 19 (Monday).—SIR JAMES FORTESCUE-FLANNERY, Bt., Ex-President, Institution of Marine Engineers, "Marine Internal Combustion Engines." THE RT. HON. LORD BEARSTED will preside.

MAY 21.—PROFESSOR C. VERNON BOYS, F.R.S., "Calorimetry." (Trueman Wood Lecture.)

MAY 28.—MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Dates to be hereafter announced:—

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock:—

MARCH 21.—OTTO ROTHFELD, I.C.S., "Progress of Co-operative Banking in India."

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced:—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons at 4.30 o'clock:—

MARCH 4.—THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak." THE RT. HON. LORD BEARSTED will preside.

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

CANTOR LECTURES.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

Syllabus.

LECTURE I.—FEBRUARY 25.—The carbonisation of coal considered as a process for distributing the thermal energy of the coal into therms in the form of gas, tar and coke. Factors which cause wastage of therms in the form of gas and the principles underlying high yields of gaseous therms.

LECTURE II.—MARCH 3.—The inter-relation of therms in the form of gas and tar and the process conditions which affect their distribution. Further principles underlying high yields of gaseous therms. The chemistry and economics of tar cracking.

LECTURE III.—MARCH 10.—The trend of developments in carbonising processes. The de-ashing of coal and other factors tending to increase the value of the therm in the form of coke.

COBB LECTURES.

Monday evenings, at 8 o'clock:—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 18..British Architects, Royal Institute of, at the Royal Society, Burlington House, Piccadilly, W., 8 p.m. Mr. Paul Waterhouse, "The Charing Cross Bridge."

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Prof. G. M. Price, "Geology in its relation to Scripture Revelation."

Transport, Institute of, at the Institution of Electrical Engineers, Victoria Embankment, W.C., 5.30 p.m. Mr. R. C. Reynolds, "Salient Points in Transport Accountancy."

Electrical Engineers, Institution of, (Informal Meeting), 7 p.m. Dr. E. M. Malek, "Electrical Development in France."

Faraday Society, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1. Principal A. P. Laurie, "Suggestions for a Magnetic Theory of Valency." 2. Prof. T. M. Lowry, "The Electronic Theory of Valency. Part IV. The Origin of Acidity." 3. Messrs. E. Hatschek and R. H. Humphry, "On Certain Physical Differences between Sols and Gels of Agar." 4. Profs. D. C. Henry and A. V. Morris, "The Influence of Anions in the Coagulation of a Negative Colloidal Sol." 5. Messrs. E. B. R. Prideaux and W. E. Crooks, "The Diffusion Potentials of Benzoates and Salicylates and their Modification by Membrane of Parchment Paper."

Geographical Society, Lowther Lodge, Kensington Gore, S.W., 5 p.m. Mr. E. Heawood, "The Use of Watermarks in Dating Old Maps."

University of London, University College, Gower Street, W.C., 5.15 p.m. Dr. A. S. Parkes, "The Mammalean Sex-Ratio." (Lecture IV.)

At Kings College, Strand, W.C., 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture III.)

5.30 p.m. Dr. R. W. Seton-Watson, "A Survey of Bohemian History." (Lecture III.)

East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Mr. J. C. French, "Continuity in Indian Art."

TUESDAY, FEBRUARY 19..Statistical Society at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m. Mr. R. Y. Sanders, "Foreign Trade and Shipbuilding."

Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Messrs. J. F. Caine and E. A. Marx, "Some Aspects of Railway Lighting."

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Anthropological Institute, at the Royal Society, Burlington House, Piccadilly, W., 8.15 p.m. Dr. E. Jones, "Psycho-Analysis and Anthropology."

Mineralogical Society, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. J. Barcroft, "The Respiratory Pigments in Animal Life." (Lecture II.)

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. P. King, "The Camera and the Human Eye: a Comparison."

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. D. H. Owen, Experiment on a Cylindrical Steam Boiler with and without pre-heated Air."

Embroiderers' Guild, at the Victoria and Albert Museum, South Kensington, S.W., 3 p.m. Capt. Kettlewell, "The Heraldry and Arrangement of Banners."

University of London, University College, Gower Sttreet, W.C., 5.30 p.m. Mr. J. H. Helweg, "Modern Danish Lyrics 1870-1920." (Lecture III.).

5.30 p.m. Mr. N. H. Baynes, "The Roman Empire and its Invaders." (Lecture III.)

At King's College, Strand, W.C., 5 p.m. Rev. Prof. F. C. Burkitt, "Christian Beginnings." (Lecture III.)

5.30 p.m. Sir Bernard Pares, "Russia Before Peter the Great to 1861." (Lecture V.)

5.30 p.m. Dr. H. W. Carr, "The Transition to the Relativist Conception of Nature." (Lecture III.)

5.30 p.m. Mr. J. R. Beard, "Electric Power Mains." (Lecture III.)

WEDNESDAY, FEBRUARY 20.. United Service Institution, Whitehall, S.W., 3 p.m. Air-Commander A. H. Clark-Hall, "The Value of Civil Aviation as a Reserve in the Royal Air Force in the Time of War."

Meteorological Society, 49, Cromwell Road, S.W., 7.30 p.m.

Transport, Institute of, (Local Section), The University, Liverpool. Prof. E. R. Dewsnup "Some Aspects of the Problem of Inland Transport."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. F. Hughes, "Can Industry be Divorced from Politics?"

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C., 6 p.m. Prof. R. Muir, "The Institutions of the Empire."

University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. Geyl, "English Diplomacy in Holland in the XVIII. Century." (Lecture II.)

5.30 p.m. Mr. I. C. Gróndahl, "Contemporary Norwegian Literature." (Lecture III.).

5.30 p.m. Mr. J. G. Pearce, "The Work of Special Libraries and Intelligence Bureaux in Industry."

6. p.m. Prof. Karl Pearson, "The Current Work of the Biometric and Eugenics Laboratories." (Lecture II.)

At King's College, Strand, W.C., 5.30 p.m. Mr. A. Vallance, "Old Timber Houses."

THURSDAY, FEBRUARY 21.. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. H. H. Thomas, "Aerial Photography and Survey."

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. Sir W. Bragg, "Crystalline Structure of Organic Substances." (Lecture III.)

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Mr. T. Dean, "The Dalton Plan in Practice."

Constructive Birth Control, Society for, Essex Hall, Strand, W.C., 8 p.m. Dr. Maude E. Kerslake, "Why we want Clinics."

Economics and Political Science, London School of, Houghton Street, Aldwych, W.C., 5 p.m. Sir Hubert L. Smith, "The Economic Laws of Art Production." (Lecture VI.).

Linnean Society, Burlington House, Piccadilly, W., 5 p.m.

Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1. Messrs. T. M. Lowry and E. M. Richards, "The rotatory dispersive power of organic compounds. Part XI Octyl Alcohol and Octyl Oxalate." 2 Messrs. J. O. Cutter and T. M. Lowry, (a) "The Rotatory Dispersive power of organic compounds. Part XII. Borneol, Camphor and Camphorquinone. Asymmetric atoms and asymmetric molecules." (b) "The Rotatory Dispersive Power of Organic compounds. Part XIII. Halogen-derivatives of camphor. Optical superposition in the camphor series." 3. Mr. H. Hunter, "Investigations on the Dependence of Rotatory Power on Chemical Constitution. Part XXII. Simple and complex rotatory dispersion.'

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. I. Bjórkhagen, "Modern Swedish Prose Authors." (Lecture III.)

5.15 p.m. Prof. J. E. G. Montmorency, "Comparative Customary Law in Europe and Asia." (Lecture V.)

At King's College, Strand, W.C., 5.30 p.m. Dr. E. W. Scripture, "The Psycho-Analysis of the Poet."

5.30 p.m. Prince D. S. Mirsky, "The History of Russian Literature." (Lecture V.)

5.30 p.m. Dr. H. Lamb, "The Internal Constitution of this Earth." (Lecture II.)

At the London School of Economics, Houghton Street, Aldwych, W.C., 5 p.m. Dr. J. H. Clapham, "Britain on the Eve of the Railway Age." (Lecture I.)

At St. Mary's Hospital Medical School, Praed Street, W., 5 p.m. Prof. B. J. Collingwood, "Blood." (Lecture I.)

London County Council, Geffrye Museum, Kingsland Road, E., 7.30 p.m. Mr. H. A. Tipping ("Furniture" Part I.), "The Dining Room from the Earliest Times to the Present Day."

Tropical Medicine and Hygiene, Royal Society of, 11, Chandos Street, W., 8.15 p.m. Prof. F. Kleine, "Recent Expedition to Africa to Investigate the Action of Bayer 205."

FRIDAY, FEBRUARY 22. Engineering Inspection, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. Mr. M. W. Baseden, "The Oscilloscope."

Royal Institution, Albemarle Street, W., 9 p.m. Prof. G. Elliot Smith, "The Human Brain."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. C. P. Crowther, "Portraiture and Portable Lighting."

Physical Society, at the Imperial College of Science, South Kensington, S.W., 5 p.m.

Aeronautical Engineers, Institution of, Engineers' Club, Coventry Street, W., 6.30 p.m. Mr. W. O. Manning, "Low-powered Flying."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Annual General Meeting.

University of London, at King's College, Strand, W.C., 5.30 p.m. Dr. H. Lamb, "The Internal Constitution of the Earth." (Lecture II.)

5.30 p.m. Prof. R. W. Seton-Watson, "The Rise of Nationality in the Balkans." (Lecture V.)

5.30 p.m. (Shakespeare Assoc.) Prof. S. Boyanus, "The Beginnings of English Stagery."

At the London School of Economics, Houghton Street, Aldwych, W.C., 5 p.m. Prof. A. P. Brigham, "The Geography of the United States, Regional and National." (Lecture I.)

SATURDAY, FEBRUARY 23.. Royal Institution, Albemarle Street, W., 3 p.m. Mr. W. de la Mare "Imaginative Prose."

London County Council, Horniman Museum, Forest Hill, S.E., 3.30 p.m. Miss M. A. Murray, "Animals in the Religion of the Ancient Egyptians."

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FRIDAY, FEBRUARY 22, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 25th, at 8 p.m. (Cantor Lecture.) EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Lecture I.

WEDNESDAY, FEBRUARY 27th, at 8 p.m. (Ordinary Meeting.) CHARLES S. MYERS, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The use of Psychological Tests in the Selection of a Vocation." SIR ROBERT BLAIR, LL.D., Education Officer, London County Council, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

COUNCIL.

A meeting of the Council was held on Monday, February 11th. Present:—

Lord Askwith, K.C.B., K.C., D.C.L. (in the Chair); Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Mr. A. Chaston Chapman F.R.S.; Sir William Henry Davison, K.B.E., D.L., M.P.; Mr. Edward Dent, M.A.; Mr. P. M. Evans, M.A., LL.D.: Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Sir Philip Magnus, Bt.; Dr. William Henry Maw, M.Inst.C.E.; Hon. Sir Charles A. Parsons, K.C.B., LL.D., D.Sc., F.R.S.; Mr. Alan A. Campbell Swinton, F.R.S.; Mr. Carmichael Thomas; Dr. J. Augustus Voelcker, M.A., and Sir Frank Warner, K.B.E.; with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

PROFESSOR C. VERNON BOYS, F.R.S., was appointed to deliver the Trueman Wood lecture on "Calorimetry."

SIR FRANK BAINES, C.V.O., C.B.E., was appointed to represent the Society on the Chadwick Trust.

Arrangements for papers and lectures were considered.

Other formal business was transacted.

SWINEY PRIZE.

A meeting of the adjudicators of the Swiney Prize, appointed under the will of the late Dr. George Swiney, was held at 5 p.m. on Monday, February 11th, 1924, at the house of the Royal Society of Arts. Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, was in the chair.

The CHAIRMAN reported that the Committee appointed by the Council of the Royal Society of Arts, had examined the works submitted for the prize, and were unanimously of opinion that the prize should be awarded to Sir Paul Vinogradoff, for his work, "Outlines of Historical Jurisprudence."

On the motion of the CHAIRMAN, seconded by SIR HUMPHRY ROLLESTON, K.C.B., M.D., D.C.L., LL.D., President of the Royal College of Physicians, it was thereupon unanimously resolved: "That the Swiney Prize be adjudged to PROFESSOR SIR PAUL VINOGRADOFF, F.B.A., for his work, 'Outlines of Historical Jurisprudence.'"

TENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 13th, 1924: SIR ASTON WEBB, K.C.V.O., C.B., P.R.A., a Vice-President of the Society, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Franzen, Raymond, Ph.D., Berkeley, California, U.S.A.

McCall, William A., Ph.D., New York City, U.S.A.

Mattu, Pandit Jagar Nath, Srinagar, India.

Shaw, Professor Frederick William, B.S., M.D., Rolla, Missouri, U.S.A.

The following candidate was duly elected a Fellow of the Society:—

Aslam, Syed Mohammad, B.A., Oxford.

A paper on "The Preservation of Timber Roofs from the Death-Watch Beetle," was read by PROFESSOR H. MAXWELL-LEFROY.

The paper and discussion will be published in a subsequent number of the *Journal*.

INDIAN SECTION.

FRIDAY, FEBRUARY 15th, 1924. The RIGHT HON. LORD MESTON, K.C.S.I., LL.D., in the Chair.

A paper on "Salt Manufacture in India," was read by SIR RICHARD M. DANE, K.C.I.E., Commissioner, North India Salt Revenue, 1898-1907, and Inspector-General of Excise and Salt for India, 1907-09.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

NINTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 6TH, 1924.

LORD ASKWITH, K.C.B., K.C., D.C.L. (Chairman of the Council) in the Chair.

THE CHAIRMAN, in introducing the lecturer, said he was not going to say one word about the calamity which was the subject of the paper, because he desired the audience to hear of it first-hand, from one who knew about it through his relatives and friends in Japan, and who would show films of the actual event. Mr. Iyemasa Tokugawa was a gentleman now in the Japanese Embassy in London. He had been in London in his youth for several years; had then been Secretary to the Foreign Office in Tokio, at the outbreak of the War; had afterwards gone to Pekin and Washington, and had then returned to this country. Mr. Tokugawa was, therefore, well-known in England, and knew the English. Further, Mr. Tokugawa spoke as a man bound up with Tokio by his ancestry and by his own life. For generations the family of Tokugawa had been connected with Tokio. The lecturer's grandfather, after 15 generations of the Shogunate which they had established in Tokio (then, he thought, called Yédo)—had been the last Shogun, and when the Shogunate gave place to the Imperial dynasty, the son of the last Shogun (now President of the House of Peers in Japan) was given the dignity of a Prince. He, with his son, was present at the Disarmament Congress at Washington on behalf of his country, and at the present time was the head of the local Organisation in Tokio, in addition to being connected with the various Imperial, Foreign and National enterprises, for the relief of the terrible distress which had arisen in consequence of the calamity. Mr. Tokugawa, the son of Prince Tokugawa, therefore, spoke about a city which was in his blood by his ancestry, and by his own connection with it. He spoke of it with sympathy and with knowledge, from the accounts which had come from his near relatives in that neighbourhood, no one of whom, he was glad to say, had died in the catastrophe which had proved such a tragedy to so many families.

The paper read was :—

THE EARTHQUAKE AND THE WORK ON RECONSTRUCTION IN JAPAN.

By IYEMASA TOKUGAWA, O.B.E.,
First Secretary to the Japanese Embassy.

It is a very great honour and privilege to give such a distinguished and learned gathering to-night some account of the recent earthquake disaster in Japan and the work of reconstruction now in progress. I must tell you first of all that as I have not been an eye-witness of the horror, my account of the catastrophe is based on official and other reports, on letters from my friends and relatives in Japan, and also on what has been told by those who have come to London after their terrible experiences in Tokio or Yokohama.

Before proceeding to the main topic of my paper, it may perhaps be better to lay before you a very general topographical description of Japan, and, in particular, the districts which were affected by the earthquake. To those of you who have been to Japan, this may seem superfluous, but, for others who are not quite so familiar with the geography of Japan, just a few words on that subject may be acceptable.

Japan proper, if we omit Corea for the moment, is a long cluster of islands extending over about 37 degrees of longitude and 29 degrees of latitude. There are six large islands. The largest one, Hondo, that is the main island, lies in the middle. Hokkaido, next in size, is up in the north. Still further north, there is Saghalien, the southern half of which is Japanese, the other half being Russian. The other three are Kyushu, Taiwan—that is, Formosa,—and Shikoku, in order of size. For the present purpose, we shall confine our attention only to Hondo, the Main Island. The Pacific Ocean washes the eastern shores of this island, and at a point not far from the north-east coast, there is the deepest sea bed in the world ever surveyed, called, after the name of the American warship, Tuscarora Deep. However, this is by the way. Coming down southward along the north-eastern coast I have mentioned, almost the first bay worthy of attention is the Bay of Tokio, with the Boso and Miura Peninsulas on both sides. Tokio, the capital, is situated at the inside of the Bay, and Yokohama, one of the chief sea ports

of Japan, especially in relation to the trade with America, is about 20 miles south of Tokio on the west coast of the Bay. Further south on the same side of the Bay, there is Yokosuka, the oldest and one of the largest naval stations in Japan. Westward from Tokio Bay, there are many indentations of considerable size. On the west side of the Miura Peninsula, there is the Sea of Sagami, in the centre of which there is a volcanic island called Oshima, and, on the coast, there are famous sea-side resorts, such as Dzushi, Kamakura, Enoshima, Oiso, etc. On the other side of the bay, there lies the Idzu Peninsula, which, on its west, has the Bay of Suruga. The next bay is the Bay of Isé, and then, there is the Kii Channel, which divides the Main Island from Shikoku. If you proceed up that channel to the north, you find the Bay of Osaka. Another sea-port of international importance, Kobé, is on the west coast of it, and, at the inside of the bay, there is Osaka, another seaport of less international importance, but the greatest industrial city in Japan.

One of the main railway lines,—as a matter of fact the most important line,—called the Tokaido Line, connects Tokio and Kobé, running practically all the way along the Pacific coast, and extending further westward from Kobé to Shimonoseki, almost the westernmost point of the Main Island. There is another railway called the Nakasendo Line, running more inland parallel to the Tokaido Line, although it joins the Tokaido Line somewhere near the Bay of Isé. At the other end of this system is a station on a railway running northward from Tokio. Thus, in case of need, when the Tokaido Line is not available, as sometimes happens after a typhoon which visits the Pacific coast at the end of almost every summer, this Nakasendo Line serves as a substitute for the former, although in a much more round-about way.

The main Island is traversed from north to south by a range of mountains. The most famous is Mount Fuji, which stands about ten miles to the north of the sea-coast of the Bay of Suruga. Its remarkable grace, its shape almost symmetrical all round makes it one of the most beautiful mountains in the world. Near Mount Fuji starts the Hakoné range, which runs southward into the Idzu Peninsula. This is famous for the numerous hot springs in the Hakoné districts. The name of Miyanoshita is probably quite familiar to you, and it is the most popular resort in the neighbourhood.

The whole of Japan is divided in prefectures for administrative purposes. Greater Tokio constitutes a prefecture by itself. To the east of Tokio, there is the Chiba Prefecture, which practically covers the Boso Peninsula already mentioned. Yokohama, the whole Miura Peninsula and the other Sagami districts, which cover the greater part of the sea-board of the Bay of Sagami, are in the Kanagawa Prefecture. To the north of Tokio, there is the Saitama Prefecture, while on the other hand the greater part of the Idzu Peninsula is in Shidzuoka Prefecture. I mention these Prefectures, because these were wholly or partially affected by the earthquake.

Now let us come back to the question of the earthquake itself.

Japan experienced a very hot summer last year, and, on the morning of Saturday, September 1st, there was a strong gale in Tokio and its neighbourhood, and had it continued to blow, as was feared naturally enough at this time of the year, it might indeed have caused by itself considerable damage. But by 10 o'clock in the morning of that day, the gale ceased, and everybody in town and in the country was looking forward to the enjoyment of a quiet late summer Saturday afternoon. In Japan, noon is the lunch time, and that hour had almost arrived, when at eleven o'clock, fifty-eight minutes and forty-seven seconds, suddenly an extraordinary rumbling of the ground was heard, and a moment had scarcely passed, when the first violent shock of earthquake started the work of terrible destruction. It came brutally, tossing up and then mercilessly shaking the earth over a very wide range. Everybody and everything on earth lost all control. It is no exaggeration to say that people thought it was the end of the world.

According to the personal narrative of the captain of a Canadian liner which was then in the harbour, he saw the whole flat city of Yokohama billowing like the surface of the ocean under a great storm, and all the houses and vehicles seemed exactly like ships drifting about at the mercy of the waves. The next moment clouds of dust caused by the falling of houses covered the scene, and then the smoke from the fire which followed blotted the whole city out of sight.

One earthquake shock followed another; during the first twelve hours about 114 shocks were experienced; during the twelve hours following, there were 88; during the third 60, and during the fourth 47, and so on, and some of them were almost as severe as the first. If you add to these the other shocks which a seismograph alone could record, there were, during the first three days, more than 1,700 shocks in Tokio. This was not all. Shocks were felt almost every day, although gradually diminishing in violence, until November. Of course, these shocks were not all very violent ones, but the first shock was not the only one that had fatal results.

Now, what was the cause of the earthquake? According to the official report of the Central Meteorological Observatory in Tokio, the earthquake seems to have been caused by a subsidence of earth in the south-western part of the Sea of Sagami, with a reaction of a rise of earth in the southern part of the Province of Sagami, including the Miura Peninsula, as well as the Boso Peninsula. The subsidence near Oshima in the Sea of Sagami was between forty and fifty fathoms and there was a corresponding or even greater rise elsewhere. The above-mentioned provinces, including hot spring resorts such as Atami and Miyanoshita as well as sea-side resorts such as Kamakura, Oiso and also the naval station of Yokosuka were the points most affected by earthquake. Yokohama and Tokio, especially the latter, were, comparatively speaking, less affected, so far as the result of the earthquake itself was concerned.

In Tokio and Yokohama, however, the smaller seismic damages were surpassed by the terrible forces of fire, which was directly caused by the earthquake. Owing to the collapse of roofs and ceilings, the cracking of walls and panels, coupled with the breaking down of electric wires as well as the blowing up of gas mains, fire broke out at many different places simultaneously in Tokio and Yokohama. That it was the cooking hour of noon also accounted for the spread of the conflagration, the charcoal fires being overturned, or things turned over them, almost everywhere.

In Tokio, for instance, four places were already on fire at noon,—only a minute or two after the first shock of earthquake, and, in the course of another few minutes fifty-three separate outbreaks were reported. The fire brigades were promptly in action, but their forces were far from being sufficient for such a wholesale conflagration, and it must not be forgotten that the waterworks and mains throughout the city were quickly out of working order. Besides, the wind began to blow hard again, and, from Saturday evening to Sunday, there were twenty-two fresh outbreaks of fire, thus increasing the whole number to no less than eighty-three. The fires which orginated in different parts of the city, eventually joined together and swept over the greater part of Tokio, especially involving the chief business centre of the city. Twelve out of the fifteen wards of the city of Tokio were either wholly or partially on fire, and indeed at some places, where advancing conflagrations met and became one, there arose huge whirlwinds of flame, which added to the horrors of the catastrophe. Moreover, the direction of the wind changed at about 6 o'clock on the Saturday evening, and places which had hitherto been considered safe were brought, in an instant, into the vortex of the advancing fire, and thousands who had thronged to those places in search of refuge now found themselves in the midst of the conflagration, and were burned to death. The most horrible example of this occurred on a large vacant piece of ground in Tokio, where thousands of people had gathered, not only on account of its size, but because the fire appeared to be definitely moving away from it. But when the wind veered round, as I mentioned before, the people were so tightly jammed and packed together that they had no time to make their escape and thirty-thousand hapless souls met their end on that spot. On the other hand, there were cases in which houses that would have been consumed the next moment, owed their salvation solely to this sudden turn in the direction of the wind. Conversely, many who were striving hard to rescue their wives and children who were buried alive under the debris of their houses, were themselves burnt to death together with those they were trying to save. People naturally thought that the bridges over the Sumida, the Thames of Tokio, were among the safest places of refuge, and every one of those bridges was densely packed with hundreds of people. All of the bridges, but one, however, in spite of their iron structure, took fire, and fell, with

every soul, old and young, upon them, into the river. The rest needs no telling.

In Yokohama, a portion of the staff of a large Japanese Bank, for example, hurried into the stone building for the purpose of closing the fire-proof shutters, but before they could get out of the building, fire surrounded it and all were roasted to death.

The above are only a few examples of hundreds of thousands of dreadful scenes witnessed in Tokio, Yokohama and elsewhere, and to enumerate more would simply be horrible. One cannot but picture, however, what a pitiful sight it must have been when the survivors, men, women and children, having lost their homes and all or most of their personal effects were huddled in groups, here a few and there a few, in all the safer open spaces, such as the parks or squares, spending night after night in the open air, others wandering about from place to place in grief and in despair, still cherishing the hope of finding their relatives, somewhere, either living or dead! And all these things were happening in the midst of further frequent shocks, great and small, which still froze the hearts of all with terror.

The Imperial Palace in Tokio, which is surrounded by moats, and the Houses of Parliament as well as some Government buildings were saved, while nearly all the large commercial establishments were tota ly or partially destroyed. Some of the Foreign Embassies and Legations were also damaged. The more hilly part, that is the north western district of Tokio, generally escaped the conflagration. My parents live in that part of Tokio and their house was not in danger, although my mother writes, in one of her letters, that, for about a week, they had no electric light and no gas fire and only a few candles. "But," she continues, "for the first two nights, there was no need of lighting, for, although our house was far from where fires were raging, one could see quite well in the house at night on account of the glare from the burning houses."

In Yokohama, the effect of the earthquake itself was more severe than in Tokio, and nearly the whole city was turned in a day, or one might even say in a few hours, into a scorched field. Here the explosion of oil tanks made things worse and the whole harbour was full of floating oil. By Sunday morning, patches of oil took fire and at one time the flames went up to a height of 200 to 300 feet. The canals, or creeks, as they are called, winding though the city, were also changed into blazing lanes, and people pursued by raging flames on land were flung in their flight into these fiery waterways, and perished. Yokosuka, where there is the well-known naval station and arsenal; Kamakura, famous for its temples and shrines and also as a sea-side summer resort; Oiso, another sea-side resort, Hakoné, the hot spring districts and other places bordering on the sea of Sagami, were all severely damaged. Furthermore, these sea-side places suffered in addition under the visitation of tidal waves, which, however, were not so great as first reported. Any one who has been to Kamakura and its neighbourhood must have visited Enoshima, the island of about 2 miles in circumference near Kamakura. That island was once reported to have entirely disappeared, but this is certainly an exaggeration.

The exact number of casualties is still very difficult to establish. Figures appearing in the latest official report are as follows:—

IN THE CITY OF TOKIO

Dead	67,106
Missing (practically speaking to be assumed all dead)	34,536
Injured	41,296

IN YOKOHAMA

Dead	23,440
Missing	3,183
Injured	24,053

Owing to the death of the Prime Minister, Admiral Baron Kato, toward the end of August, the Japanese Cabinet had just tendered its resignation, and when the earthquake came, no new Cabinet had yet been formed. So on the day of the earthquake, outgoing Cabinet Ministers assembled in Council, and, as an emergency measure, the Tokio and the neighbouring afflicted prefectures were at once placed under Martial Law. Count Yamamonto formed a Cabinet the next day in the midst of the burning city, and the first cabinet meeting was held in the open air. Thus, the work of relief and reconstruction was embarked upon. On September 2nd, the Emergency Requisition Ordinance was issued with a view to obtaining the materials and labour necessary for the relief of sufferers in the devastated districts. On the same day, the Provisional

Earthquake Relief Bureau was established under the direct control of the Prime Minister. On September 7th, three further important ordinances were issued; (1) Ordinance regarding moratorium, authorising the postponement of the discharge of private debts for a month, (2) Ordinance prohibiting profiteering and (3) Ordinance forbidding the circulation of alarming rumours calculated to disturb public order or instigate crimes. Several other similar emergency measures were designed and put in practice one after another, such as the exemption or reduction of certain kinds of taxes in favour of earthquake sufferers, temporary abolition of the import duty on rice, necessaries of life, reconstruction materials, etc. A little later, two Government organisations were established, one for the purpose of setting up plans for the reconstruction, and the other for the working out of those plans. In addition to these Government measures, all sections of the whole nation have been displaying activity and have done and are doing much good work for the restoration of trade and the restitution of normal life in the devastated districts. The Emperor lost no time in contributing Y 10,000,000 (about £1,000,000) in aid of the relief of sufferers, an association was organised by eminent business men, members of both houses of Parliament and others, for the purpose of affording facilities to the rescue work, and the Japanese Red Cross Society and other medical and charity associations organised temporary infirmaries and relief corps for the gratuitous treatment of sufferers and the distribution of food and water. The Red Cross, for instance, put up large barracks in the compound of its hospital in Tokio to accommodate 300 sick and wounded and 50 infectious cases, and also in the four most afflicted wards of Tokio for 600 sick and wounded. Similar arrangements were made in other devastated districts outside of Tokio, while in prefectures which were not affected, relief organisations were rapidly made at such places as piers, railway stations, etc., for the refugees who began to arrive from the devastated districts and who increased in numbers from day to day.

The transport of the refugees was wonderfully well carried out by the co-operation of the military and naval authorities on the one hand and steam ship companies and railway authorities on the other. Besides, foreign passenger and cargo ships also did admirable work in this direction. The "Empress of Australia," a Canadian liner, for instance, which was just on the point of leaving the pier of Yokohama for Vancouver, when the earthquake came, took as many refugees on board as she could, both foreign and Japanese alike, and gave them food and drink as well as medical attention, subsequently undertaking their transport to Kobé and further on to Shanghai. The American Oriental Squadron too, afforded wonderful help. The whole fleet which hurried from Chinese waters to Japan, on the timely initiative of the American Ambassador in Tokio, arrived at Yokohama with a large quantity of provisions only four days after the earthquake. Ships also arrived later from America with food, clothing, blankets, building materials, etc. In almost every country throughout the world, a relief fund was promptly started. Here in London, the late Lord Mayor instituted a Mansion House Fund, which realised some £262,000, a great achievement. Their Majesties the King and Queen graciously contributed £500 and £250 respectively, H.R.H. the Prince of Wales also £250. There were also contributions from T.R.H. the Duke and Duchess of York and the Duke of Connaught. Balls and concerts in aid of the relief were organised in London and the country. The Japan Relief Supply Committee was also formed in London by prominent English ladies and gentlemen, and by their efforts, a large quantity of useful things for the immediate use of sufferers have been dispatched to Japan. All this help from foreign authorities and residents in Japan, as well as from abroad, is most appreciated in Japan. The whole nation has regarded so liberal and concrete an expression of sympathy from every part of the world with feelings of profound gratification.

All the means of communication as well as electric, gas and water supply were dislocated by the earthquake, but stringent efforts were made in every direction, and generally a rapid recovery was secured. As regards the electric street tramway of Tokio, for example, the majority of the cars were destroyed by fire, but a certain short section opened traffic as early as September 6, and already toward the end of the third week of that month, the repair of lines was made to the extent that

about 500 out of more than 900 surviving cars were in actual service, and it is hoped that by now tram communications in the whole city have become practically normal. The gas supply was also re-established to a satisfactory degree in a comparatively short time. Moreover, the enormous decrease in the power supply consequent upon the loss by fire of some of the gas holders, has balanced the more than corresponding decrease in demand due to the destruction of the busiest part of the city. Out of about 50 electric power stations in Tokio, 30 were placed in working order within a week, and certain restrictions were at first imposed, such as on the number of lamps to be lighted. However, it hardly took ten days before electric lighting in Tokio and its suburbs was brought back almost to its normal state. The postal, telegraph and telephone services were all suspended, but I gather that the first two services have to a great extent been restored, while as to the telephone service, which lost not only the majority of the exchanges in Tokio, but as many as 62,000 apparatuses, communication was possible by the end of a month between only a very limited number of establishments which had direct and important bearings on state affairs and the work of reconstruction and relief. The complete restoration of the telephone system will probably take more than a year. Railway disasters in devastated districts were numerous, owing to the fall of bridges, the collapse of tunnels, viaducts, etc., to say nothing of simple derailings and similar happenings. From September 3rd the unaffected lines and sections were opened for free passenger traffiic, and two days later northbound trains from certain surburban stations were packed with refugees from Tokio, and carried passengers even on the roofs of the carriages. Direct railway connection between Tokio and Western Japan was missing, but one could go up north to a certain point and go down west by the Nakasendo or Midland line, which runs through the Kiso Mountains. Yokohama and other places in, and the east of the Hakone mountains were isolated, and refugees could be carried westward only by sea. The through railway service between Tokio and Kobé was resumed on October 28th, and as before the earthquake, Kobé is now reached from Tokio in less than 13 hours.

Thanks to the extensive emergency repairs carried out in harbour and canal accommodation in Tokio and Yokohama, coupled with the valuable efforts of banking institutions and others interested, the first export of raw silk since the earthquake from the extensively damaged port of Yokohama, took place as early as September 17th.

A matter which needed the most urgent attention, especially in Tokio, was the provision of shelter for homeless people. The Government, while prohibiting the construction of any building of a permanent nature, pending a decision on a new general scheme of town planning for Tokio, authorised by an ordinance the construction of temporary buildings, on which, however, work had to be started before March 1st, 1924, the buildings having to be removed before September 1st, 1928. The Government and the municipal and other authorities lost no time in selecting open spaces, such as public parks and the available ground at shrines, temples and schools, for the construction of temporary wooden barracks. In each of these groups of barracks a certain degree of self-government is allowed to its dwellers, thus giving them the appearance of independent villages. The grounds of some of the Imperial Detached Palaces in Tokio were generally open to the public for this purpose. Temporary wooden shops and offices put up by individual merchants and firms are also rapidly increasing in number—some on their old business sites, and others on sites provisionally acquired. On the other hand, it is interesting to note that shops in some rather out-of-the-way quarters, which were not affected by the earthquake and fire, are now doing a flourishing trade on account of the disappearance of most of the large shops in the more central parts, as well as of the removal of customers to these unaffected districts. That is just what would happen in such places as Finchley Road or Fulham Road, for instance, if all the west end shops suddenly disappeared, and the Mayfair customers were transplanted to North Hampstead or Chelsea!

The destruction of innumerable public schools, too, caused a great deal of anxiety, and open air classes and lectures, are being extensively arranged by the municipalities, by various educational or religious institutions and also by private individuals.

The whole library of the Imperial University was burnt to ashes and the authorities are doing their utmost to replace the books as far as possible, but there were

many old documents, manuscripts, etc., for which there are no substitutes in the world, and these can never be replaced. Here in England, the British Museum, the Universities Bureau of the British Empire, the League of Nations Union, and other bodies and institutions have kindly made offers of contributions of books, and over 1,700 valuable volumes have already been received at the Embassy for transmission to Tokio. In addition, on the initiative of the British Academy, under the able and considerate direction of its President, Lord Balfour, an executive committee, representing different learned bodies, including those I have mentioned, and the leading publishers in this country, has been formed in order to centralise efforts in this direction.

In Japan, the ordinary session of Parliament meets every year towards the end of December, the actual business commencing in January, in order to consider, among other things, the budget of the ensuing fiscal year, but last year it was found necessary that a special session should be convoked at the beginning of December for the purpose of considering various emergency measures which the Government had undertaken since the earthquake on its own responsibility, subject to the subsequent approval of Parliament, for the Japanese Constitution recognises such steps as lawful, when, owing to the urgent nature of the matter, the ordinary assembling of Parliament cannot be awaited. This special session had also to consider many material alterations which, in consequence of the catastrophe, had been found necessary in the existing budget for the rest of the current fiscal year. I shall refrain from the enumeration of dry figures, but may perhaps, be permitted to give you some idea of the scope of the work of restoration necessary in the Tokio and Kanagawa Prefectures, of the latter of which Yokohama is the capital. The gross total of the estimated cost for the restoration of Tokio and Yokohama, extending over seven years from 1923 to 1929, which has so far received the approval of Parliament is Y468,438,849. Of that amount, the expenditure on the rebuilding work to be undertaken by the State is Y342,192,800, of which again a little less than 90 per cent. is for the reconstruction of Tokio, and the remainder for that of Yokohama. The above gross total also includes advances to the Tokio and Kanagawa Prefectures of Y15,325,402, and the Government subsidies to these Prefectures, as well as to the cities of Tokio and Yokohama, to the amount of Y89,225,917. Parliament has also passed laws, authorising the Government on the one hand to give guarantees, in case of need, for both the principal and interest of loans which may be issued in foreign markets by the Tokio and Yokohama municipalities to the face value of Y100,000,000 and Y40,000,000 respectively, the Government being permitted, on the other, to issue on its own part in the home market public loans to the extent of Y468,500,000. The Municipalities of Tokio and Yokohama have additional reconstruction work to be executed, on their own account. The gross total of expenditure of the City of Tokio, details of which were laid before its Municipal Assembly by the Mayor of Tokio on December 26th last, is Y182,640,000. A Bill in relation to town planning also passed the Special Session of Parliament and has become law. This, however, refers simply to the organisation and procedure for the execution of town planning in Tokio and Yokohama. The concrete details of those plans are not yet known to me, although they are being worked out vigorously by the organisations concerned and I have seen several tentative proposals or suggestions. Indeed, such details, even if available, would hardly be of interest to you, and the time at my disposal would not allow me to deal with them.

I am afraid I have already trespassed on your patience too long, although, considering the magnitude of the catastrophe as well as the diversity of its consequences, I have found it extremely difficult to condense a review of all the aspects of the subject into a convenient length. In order, therefore, to supplement my insufficient account, I would like to show you some cinema films of the disaster. Some of these were taken by the direction of the Japanese Foreign Office. Others are the property of Mr. Kengo Mori, Financial Commissioner of the Japanese Government in London, who obtained them by the courtesy of the *Osaka Asahi*, a prominent newspaper in Japan. Thanks are due to Mr. Mori for the permission he has so kindly given me for their use this evening.

Before you see the earthquake films, however, I would propose to show you what Tokio looked like before, so that you

may have a more complete idea of the awful effects of the earthquake upon the capital of Japan.

DISCUSSION.

H. E. Baron Hayashi (the Japanese Ambassador) said he was sure the audience, after having listened to the paper, and after seeing the films, had realised the terrible effects of the earthquake which had devastated his country a few months ago. But they had not seen all the effects that night. They had not witnessed the scenes of the people actually dying and actually burning; they had not been able to see the buildings falling down, the railways being broken up, and so forth. Nevertheless, they must have gained an idea of what the consequences of the calamity had been. Those consequences were not those of a war or a revolution. The great destruction which had occurred had all been done in a day, or at the most two days. There was nobody against whom the Japanese nation could protest for such a happening, and that was one reason, he thought, why sympathy and help had been given to the Japanese nation, not only from this country, but from every quarter of the world. Only that morning he had received a letter enclosing a cheque which had come from Newfoundland. He had to confess that he had not been certain where that country was, although it was one of the great Dominions of the British Empire.

He congratulated Mr. Tokugawa on having given the lecture in such a calm and cool manner. Up till about 50 years ago Tokyo was the lecturer's own capital, and the people in it were his own subjects. Nevertheless, without emotion he had been able to give his lecture in the manner in which he had, and he, the speaker, congratulated him on so doing.

The Chairman said he did not think any words of his were necessary to add to the impression which the lecture and the films had made, in varying degrees, upon the minds of the audience. Therefore, he was only going to say " Thank you " to Mr. Tokugawa. He had been amazed at the English in which Mr. Tokugawa had put his thoughts. He did not suppose there was anyone of the British race present that evening, with the possible exception of General Leggett, who could speak Japanese as well as Mr. Tokugawa had spoken English. He thanked the lecturer, in the name of the Royal Society of Arts, and in the name of all those present, for his lecture.

Brigadier-General A. H. Leggett, C.M.G., D.S.O., said that, in rising to second the vote of thanks which had been proposed to Mr. Tokugawa —that illustrious son of a most noble House—he would like to add a few remarks of his own in regard to the films which had been exhibited, and the admirable address which had been given. It must have fallen to the lot of some of those present when residing in far distant lands, and in places where their own language was not often heard, to find some satisfaction and pleasure, and possibly to feel more at home, when someone had spoken to them in their own language. It was in the hope that some of his Japanese friends who were present might experience that pleasure, as he himself had done when residing in some outlying places in Japan, that he proposed to address them, very haltingly he was afraid, in the Japanese language.

(General Leggett then addressed the audience in Japanese.)

By way of explanation he would like to state very briefly what he had tried to convey to their Japanese friends. He had explained that, having been attached to the 29th Regiment of the Imperial Japanese Infantry for a considerable time, he was perhaps in a position to know better than most how the Japanese, in face of great disaster and trial, always met a great calamity. They met it with that calm courage and bravery which was characteristic of their race. He had thanked the lecturer for his admirable address and for showing the films, which had moved the audience all so much. He had ventured to express, too, the deep sympathy of Englishmen throughout the world for Japan and her people in the face of the greatest disaster of its kind which the world had ever known. Further, on behalf of the audience, and on his own behalf, he had ventured to tender their congratulations on the very happy and auspicious event which had occurred recently, namely, the marriage of the Crown Prince of Japan; and lastly, he had tried to express the audience's and his own belief that the Japanese, trusting to the wisdom which they ever derived from the spirits of their ancestors, would, upon the ashes of Yokohama and Tokyo, rebuild even greater and more beautiful cities worthy of the greatness of Japan.

Mr. Tokugawa, in reply, thanked the audience for the very cordial and generous vote of thanks which had just been accorded to him. Some very nice things had been said about his paper, at which he had felt quite overwhelmed; in fact, he was inclined to use the Japanese expression, which might be translated into English as follows: He felt he must find a hole in which to hide himself.

He also had to thank the audience for the very kind attention which they had given to his rather gloomy recital. He would have been much happier if he had been talking about the brighter side of his country. At the same time, the Japanese people were not easily disheartened. Besides that, the devastated region was only a part of Japan—although in many ways a very important part. The industrial centre of Japan, the Osaka district, still stood intact, strong and ready to help to make new Japan still newer and to build it on even stronger foundations. The cherry blossom, the chrysanthemum and the wistaria, unaware of earthquakes, fires and tidal waves,

would continue to bloom peacefully and gracefully as they had bloomed heretofore.

He was sure he was echoing the voice of the gathering that evening when he said that they owed a debt of gratitude to Lord Askwith for presiding that evening. It was indeed a very great pleasure to have had his Lordship as Chairman. He would permit himself, therefore, to propose a most cordial vote of thanks to Lord Askwith.

The vote of thanks was carried unanimously, and the meeting terminated.

LA VIE INDUSTRIELLE EN FRANCE.

Le 25e Anniversaire de la découverte du Radium et l'Institut du Radium, à Paris.

On a fêté solennellement, à la Sorbonne, le 26 décembre dernier, le 25e anniversaire de la découverte du radium, dont la science française est fière à juste titre. C'est, en effet, le 26 décembre 1898, que le Professeur Henri Becquerel présenta à l'Académie des Sciences une note de Pierre Curie et de Marie Curie, son épouse, qu'on peut considérer comme marquant le point décisif des recherches, très longues et très pénibles, de ces savants sur la radio-activité et les corps radio-actifs.

Ces recherches, qui avaient pour point de départ les études d'Henri Becquerel relatives à l'uranium et celles des époux Curie sur le thorium ont abouti, comme on le sait, à l'obtention du radium, en quantités d'ailleurs minimes. On se souvient que les Etats-Unis ont offert, l'année dernière, à Mme Curie, à l'occasion de son voyage en Amérique, un gramme de la précieuse matière, qui a été rapporté à Paris et représente l'une des principales richesses du nouvel Institut du Radium.

Celui-ci, nouvellement construit à Paris, dans le quartier de la Sorbonne, est dirigé au point de vue scientifique par Mme Curie. Il se compose de deux parties : l'une destinée aux recherches de science pure, et l'autre aux applications médicales.

Le jour même où fut célébrée en Sorbonne l'œuvre des Epoux Curie et de leurs savants collaborateurs, notamment M. Debierne, on inaugura le dispensaire de la Fondation Curie, destiné à traiter les maladies relevant du traitement au radium ou "curiethérapie" c'est-à-dire principalement les affections cancéreuses.

Pour reconnaître les grands services rendus à la science par les époux Curie, le Parlement français vient d'accorder, comme il l'avait fait autrefois pour l'illustre Pasteur, une dotation nationale, à Mme. Curie, qui consacre toute son activité à cette nouvelle branche de la physique.

Les Nouvelles Locomotives Electriques Express des Chemins de Fer du Midi.

L'électrification des Chemins de fer se poursuit en France sur plusieurs réseaux. Elle est encouragée par le Gouvernement, car elle a l'avantage de réduire les importations de charbon. Le réseau du Midi est celui où l'électrification est la plus avancée. Il utilise à cet effet l'énergie des chutes d'eau des Pyrénées. Après l'expérience de divers systèmes de traction, poursuivie depuis une quinzaine d'années, on a adopté le courant continu à 1,500 volts. La longueur totale des lignes à électrifier est de 3,300 kilomètres (2,050 miles).

Une nouvelle locomotive pour trains express vient d'être soumise à des essais officiels les 28 et 29 décembre. Cette machine attelée à un train de 300 tonnes, atteignit, 3 minutes après le démarrage, la vitesse de 100 kilomètres (62 miles) à l'heure ; peu après, le train roula normalement à 128 kilomètres (79,535 miles) à l'heure. C'est sans doute la plus grande vitesse atteinte en Europe par un train normal.

La locomotive est à deux bogies moteurs identiques ; elle comporte 4 moteurs à ventilation forcée, attaquant les essieux par engrènages ; la puissance totale est d'environ 2,250 h.p.

D'autres machines du même genre, mais moins puissantes, sont en service depuis un an pour la traction des trains de marchandises.

Toutes ces machines sont construites à Tarbes dans une vaste usine installée spécialement pour fabriquer le matériel nécessaire à l'électrification. Cette usine est celle de la Société : Constructions Electriques de France ; on y fabrique aussi des turbines, des dynamos et le matériel des sous-stations. Une autre usine construite récemment dans la même ville, fabrique les isolateurs de porcelaine pour l'équipement des lignes.

Les Essais Controlés d'Automobiles Electriques, à Paris.

Il y a une quinzaine d'années, un certain nombre d'automobiles électriques étaient en service à Paris. Elles ont disparu, parce qu'elles n'étaient pas assez perfectionnées et que les postes de recharge des accumulateurs n'étaient pas assez nombreux.

Pendant la guerre, le manque d'essence a rappelé l'attention sur ce sujet, et les Pouvoirs publics ont encouragé la construction des véhicules électriques. L'année dernière, l'Union des Syndicats d'Electricité, le Laboratoire central de l'Electricité, la Commission technique de l'Automobile Club et l'Office National des Recherches Scientifiques, ont organisé des essais officiels d'automobiles électriques à accumulateurs.

Dix-sept véhicules ont été engagés pour ces essais, qui ont eu lieu en octobre dernier ; onze voitures ont subi toutes les épreuves prévues. La charge utile variait de 250 kgs (550 lbs.) pour les camionnettes ou landaulets, jusqu'à 6 tonnes pour les camions.

Les épreuves ont duré 10 jours, et les véhicules devaient parcourir chaque jour de 50 kilomètres (31 miles) pour les camions, à 80 kilomètres (50 miles) pour les voitures légères. En réalité, la plupart ont parcouru journellement environ 150 kilomètres (93 miles) sur les routes les plus accidentés de la banlieue de Paris.

Les résultats officiels des essais n'ont pas encore été publiés. Les organisateurs ont dû promettre aux constructeurs de ne pas publier de tableau comparatif des performances des diverses voitures. Cependant, nous savons que certains véhicules ont donné des résultats remarquables. Les 3 voitures (camionnettes et coupé) d'une même marque ont fait couramment un parcours journalier de 150 kilomètres (93 miles) sans recharge de la batterie, et avec une consommation de 63 watts-heure par tonne-kilomètre du poids total, et de 275 à 400 watts-heure par tonne-kilomètre utile. En moyenne, la consommation a été de 76 watts-heure à Paris à 80 watts-heure en banlieue par tonne de poids total, pour les camionnettes, et de 60 à 70 watts-heure pour les gros camions.

Ces résultats sont des plus encourageants, et l'on a envisagé l'emploi de voitures électriques pour divers services publics. On étudie même un autobus à accumulateurs pour les transports en commun à Paris.

L'Entrepôt Frigorifique du Port de Bordeaux, a Bassens.

Depuis quelques années, on a installé dans diverses villes de grands entrepôts frigorifiques de denrées alimentaires. C'est ainsi qu'il en existe un dans le port de pêche de Lorient pour le poisson, et un à la gare des marchandises de la Compagnie des Chemins de fer d'Orléans, à Paris. Plus récemment, on a mis en service celui du port de Bordeaux, situé dans l'annexe de ce port créée pendant la guerre à Bassens, sur la rive droite de la Gironde.

Cet entrepôt est particulièrement destiné à recevoir les viandes frigorifiées de l'Amérique du Sud et il forme l'intermédiaire indispensable entre les cargos frigorifiques de la Compagnie des Chargeurs réunis et le réseau ferré de la Compagnie d'Orléans.

Pour réduire au minimum les pertes de froid pendant le transbordement des viandes, le bâtiment est construit près du quai, et lui est relié par un transporteur à courroie sans fin, abrité dans une galerie bien close. La courroie peut transporter des quartiers de bœuf de 300 kilogrammes, à la vitesse de 1 mètre par seconde.

Le bâtiment ne comprend qu'un rez-de-chaussée, de 130 x 57 mètres, divisé en 4 chambres froides d'une capacité de 1,000 tonnes de viande chacune, plus un hall de 2,500 tonnes.

La machinerie frigorifique comprend trois électro-compresseurs, à ammoniaque, donnant chacun 170,000 frigories-heure, et deux réfrigérants d'air pour la ventilation des chambres froides.

Le sol des locaux froids est dallé en liège sur 20 centimètres d'épaisseur, et les parois et plafonds sont également en briques de liège, avec couche de liège granulé de 30 centimètres.

CORRESPONDENCE.

THE SURVEY OF INDIA.

I have read with great interest the paper entitled "The Survey of India" by Col. H. L. Crosthwait, and I have particularly noticed his reference to the great weight of the mountain mass of the Himalayas, and I was reminded of a book by Prof. Joly of Dublin, who considers that the elevation of the Himalayas is due to the action of radium.

If Col. Crosthwait would deal with Prof. Joly's theories, it would be instructive to some of us.

Arnold Lupton.

NOTES ON BOOKS.

Electrical Engineering Practice. By J. W. Meares and R. E. Neale. Fourth Edition, Vol. I. London: Chapman and Hall, Ltd. 25s. net.

The characteristics which have made previous editions specially valuable to the practical man, are well to the front in the first volume of the fourth edition. These features are:—Many details and much instruction in few words, and the production of something comparable to a technical pocket-book, but on a very much larger and more complete scale; and recognition of the fact that a verbal definition or expression cannot always be indubitable in its meaning, but often requires an example or a graphic illustration.

By the application of such principles of construction or arrangement as are indicated above, the authors give us the first volume of a two-volume treatise on practical electrical engineering, which represents a concentrated aspect of the electrical practice of to-day. Vol. I embodies nearly 600 large octavo pages with many plates and 92 illustrations in the text. This new edition will more than maintain the reputation of the earlier editions.

It is somewhat disconcerting to read (p. 150), that supply meters have been and still may be in use, which by reason "of the gear wheels being only friction-tight on the spindles, may occasionally slip a notch and give a reading 10, 100, or 1000 units in excess."

The Divinity School, Oxford. By H. Edith Legge. With fifty-four illustrations. Oxford: Basil Blackwell. 2s. net.

This book, modestly described as a guide for visitors, is really a survey of the building, with special reference to the famous sculptured ceiling, and forms a valuable work of reference. It contains a large amount of information on every detail of the carvings, presented in a concise and readable manner.

Even apart from the letterpress, the book is well worth securing for the admirable illustrations, which reproduce the details of the sculptures with great fidelity, and are extremely useful for detailed study. In fact, one can appreciate the carvings better from such photographs than by examination of the originals in the ordinary way available to visitors.

The general get-up of this guide book (and the very modest price) might well be taken as a model

by those who publish similar guides to other historic buildings.

N.H.

Decorative Furniture. By George Leland Hunter. Philadelphia and London: J. B. Lippincott Company; Grand Rapids: Good Furniture Magazine. £5 5s. net.

This handsome volume should be joyfully welcomed by the student and the collector of furniture. Modestly described by the author as "a picture book of the beautiful forms of all ages and all periods" it gives examples in chronological order of furniture including Egyptian, Assyrian, Greek, Roman, Byzantine, Chinese, Japanese, Persian, Romanesque, Gothic, French Renaissance, Italian Renaissance, Later Italian, Louis XIII, XIV, XV, XVI, Directoire and Empire, Spanish, Portuguese, Flemish, Dutch, Swiss, Elizabethan, Jacobean, Charles II., William and Mary, Queen Anne, early Georgian, Chippendale, Adam, Hepplewhite, Sheraton, American Colonial, modern European and American, and American Mission. The book contains over 900 illustrations, with 23 coloured plates. Every page is a delight, and should be a fruitful source of inspiration to the designer of furniture. The specimens selected, whether single chairs, chests or tables, or completely furnished rooms, are admirable, and the manner in which the illustrations are reproduced leaves nothing to be desired.

A good many very fine specimens of panelling and other woodwork are now in America, and it is interesting to notice the effect that they have produced on modern American furniture. Particularly beautiful are the rooms modelled on the Italian Renaissance style by Charles A. Platt and the late Stanford White, while much of the American Colonial and Mission furniture, though clearly inspired by older styles, has an individuality and charm all its own.

The letterpress is wisely made subordinate to the illustrations, but it suffices to give in small space a competent account of the various periods dealt with. Mr. Hunter confesses to a personal preference for the furniture of the Italian Renaissance above that of any other period; this preference, however, does not prevent him from doing justice to all, and he writes with a very full knowledge of a vast subject.

It is not too often that one comes across a work that gives such unqualified satisfaction to the reader, and one feels that a deep debt of gratitude is due alike to the author, the publishers and the printers, for the care that they have lavished in producing this work.

THE LIBRARY.

The following books have been presented to the Library since the last announcement. Except where otherwise stated, they have been presented by the publishers:—

Abell, Sir Westcott, K.B.E. The Ship & Her Work. London: Gee & Co., Ltd., 1923.

Allen, Robert, M.A., B.Sc.—Copper Ores. London: John Murray. 1923.

Aspinall, Algernon, C.M.G.—Pocket Guide to the West Indies. London: Sifton, Praed & Co., Ltd. 1923.

Beauchamp, J. W.—Industrial Electric Heating. London: Sir Isaac Pitman & Sons, Ltd. 1923.

Belaiew, Col. N. T., C.B.—Crystallisation of Metals. London: University of London Press, Ltd.

Berger, J. A.—Executorship and Death Duties. London: Solicitors' Law Stationery Society, Ltd. 1923.

Blacker, J. F.—The A.B.C. of English Salt-Glaze Stoneware. London: Stanley Paul & Co. 1922. Presented by H. L. Doulton, Esq.

Bolton, D. J., B.Sc.—Electrical Measuring Instruments & Supply Meters. London: Chapman & Hall, Ltd. 1923.

Brendon, J. A., B.A.—Britain & Her Neighbours. Book VII. The Twentieth Century. London: Blackie & Son, Ltd. 1923.

British Journal Photographic Almanac, 1924. London: Henry Greenwood & Co., Ltd.

Burnham, Thos. H.—Special Steels. London: Sir Isaac Pitman & Sons, Ltd. 1923.

Butler, Howard Russell.—Painter and Space. New York: Charles Scribner's Sons. 1923.

Campbell, Persia Crawford, M.A.—Chinese Coolie Emigration. London: P. S. King & Son, Ltd. 1923.

Carter, E. Ellin.—Designs for Artistic Leather Work. Part I. London: E. & F. N. Spon, Ltd. 1923.

Carter, Howard & A. C. Mace.—The Tomb of Tut-Ankh-Amen. Vol. I. London: Cassell & Co., Ltd. 1923.

Conradi, Charles Guthrie, M.I.Mech.E.—Mechanical Road Transport. London: Macdonald & Evans. 1923.

Conway, Sir Martin, M.P.—The Van Eycks and their Followers. London: John Murray. 1921.

Dalton, Hugh, M.A., D.Sc.—Principles of Public Finance. London: George Routledge & Sons, Ltd. 1923.

Daniel, Percy P.—Hints for a Company Secretary. London: J. M. Ouseley & Son, Ltd.

Ellis, David, D.Sc.—A Science Course for Bakers. London: Blackie & Son, Ltd. 1923.

Fellows, E.—Colour: Charted and Catalogued. London: "Geographia," Ltd.

Fox, Cyril S., B.Sc., F.G.S.—Civil Engineering Geology. London: Crosby Lockwood & Son. 1923.

Gibbs, R. W. M., B.A., B.Sc.—Technical Arithmetic. London: Blackie & Son, Ltd. 1923.

Groves, E. J. A., Lic. ès L.—A Preparatory French Course. London: Blackie & Son, Ltd. 1923.

Hall, B. J., M.I.Mech.E.—A System of Plan Copying in Black Lines. London: Sir Isaac Pitman & Sons, Ltd. 1923.

Henri, Robert.—The Art Spirit. London: J. P. Lippincott Company. 1923.

Hervey, Mary F. S.—Holbein's "Ambassadors." London: George Bell & Sons, 1900. Presented by Miss Phillimore.

Hewitt, J. T., M.A., D.Sc., F.R.S.—Dyestuffs derived from Pyridine, Quinoline, Acridine & Xanthene. London: Longmans, Green & Co. 1922.

Hodgkinson, Thomas W.—The Director System for Cutting Ladies' Garments. Second Edition. London: Minister & Co., Ltd.

Hunter, George Leland.—Decorative Furniture. Philadelphia and London: J B. Lippincott Company.

Hyde, J. H.—Lubrication & Lubricants. London: Sir Isaac Pitman & Sons, Ltd. 1922.

Jamieson, Prof. Andrew.—A Text-Book of Heat and Heat Engines. Vol. 2. Eighteenth Edition. Rewritten by Ewart S. Andrews, B.Sc. London: Charles Griffin & Co., Ltd. 1923.

Jennings, Arthur Seymour.—The Decoration & Renovation of the Home. London: W. R. Howell & Co. 1923.

Jordan's Tabulated Weights of Iron & Steel. Eighth Edition. London: E. & F. N. Spon, Ltd. 1923.

Kaye, G. W. C., O.B.E., M.A., D.Sc.—X Rays. London: Longmans, Green & Co. 1923.

Lees-Smith, H. B., M.A., M.P.—Second Chambers in Theory and Practice. London: George Allen & Unwin, Ltd. 1923.

Lethaby, W. R.—Londinium—Architecture & the Crafts. London: Duckworth & Co. 1923.

Loring, F. H.—The Chemical Elements. London: Methuen & Co., Ltd. 1923.

Lovell, R. Goulburn, A.R.I.B.A.—Courage in Colour. London: Charles Griffin & Co., Ltd. 1922.

Macara, Sir Charles W., Bt.—The New Industrial Era. Manchester: Sherratt & Hughes. 1923.

Manning, Frederick.—Life of Sir William White, K.C.B., F.R.S. London: John Murray. 1923.

Marsh, Lewis, M.A.—A First Book of Literary Reading & Composition. London: Blackie & Son, Ltd. 1923.

Martin, L. C., D.Sc., and William Gamble.—Colour and Methods of Colour Reproduction. London: Blackie & Son, Ltd. 1923.

Meares, J. W., C.I.E., and R. E. Neale, B.Sc.—Electrical Engineering Practice. Vol. I. Fourth Edition. London: Chapman & Hall, Ltd. 1923.

Mitchell, C. Ainsworth, M.A.—The Expert Witness. Cambridge: W. Heffer & Sons, Ltd. 1923.

Moore, James M., M.A., and Mary Tweedie, M.A.—Introductory French Course. Blackie & Son, Ltd. 1923.

Nowak, Carl A., B.Sc., F.C.S.—1. New Fields for Brewers. 2. Non-Intoxicants, 1917 & 1922.

Ogata, Kiyoshi, Ph.D.—The Co-operative Movement in Japan. London: P. S. King & Son, Ltd. 1923.

Parkes, U. W. A.—Artistic Anatomy of the Human Form. London: John Bale, Sons & Danielsson, Ltd. 1923.

Peers, E. Allison, M.A.—A Skeleton Spanish Grammar. London: Blackie & Son, Ltd. 1922.

Powell, Harry J., C.B.E.—Glass-Making in England. Cambridge: University Press. 1923.

Quintus, R. A.—Cultivation of Sugar Cane in Java. London: Norman Rodger. 1923.

Redwood & Eastlake's Petroleum Technologist's Pocket-Book. Second Edition. London: Charles Griffin & Co., Ltd. 1923.

Rose, W. N., B.Sc.—Line Charts for Engineers. London: Chapman & Hall, Ltd. 1923.

Rowe, J. W. F.—Wages in the Coal Industry. London: P. S. King, & Son, Ltd. 1923.

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Rutter, Owen.—1. British North Borneo. London: Constable & Co., Ltd. 1922. 2. Through Formosa. London: T. Fisher Unwin, Ltd. 1923.

Song Ong Siang, M.A., LL.M.—One Hundred Years' History of the Chinese in Singapore. London: John Murray. 1923. Presented by Yow Ngan Pan, Esq., J.P.

South American Handbook, 1924. London: South American Publications, Ltd. 1923.

Stannus, Mrs. Graydon.—Old Irish Glass. New Edition. London: The Connoisseur. 1921.

Stefansson, Vilhjalmur.—1. The Northward Course of Empire. 2. Hunters of the Great North. London: George G. Harrap & Co., Ltd. 1922 & 1923.

Swedish Year-Book, 1924. Stockholm: Almqvist & Wiksell, Co., Ltd. 1923.

Thorpe, Jocelyn Field, C.B.E., D.Sc., F.R.S., & Christopher Kelk Ingold, D.Sc.—Synthetic Colouring Matters—Vat Colours. London: Longmans, Green & Co. 1923.

Toch, Maximilian.—How to Paint Permanent Pictures. London: Scott, Greenwood & Son. 1922.

Underwood, Edna Worthley.—The Penitent. Boston: Houghton Mifflin Company. 1923.

White, F. B. Howard, B.A.—Nickel. London: Sir Isaac Pitman & Sons, Ltd. 1923.

Woodhouse, Thomas.—Jacquards & Harnesses. London: Macmillan & Co., Ltd. 1923.

THE BACON-CURING PIG.

Writing in the *Journal of the Pig Breeders' Scientific Society*, Mr. Loudon M. Douglas, F.R.S.E., states that the weight to which a pig may be allowed to grow for bacon purposes has been modified within recent years. In the old days it was customary to fatten a pig for bacon curing up to 18 or 20 score; and in this way supply the household with fat bacon which lasted throughout the winter. Now, however, people refuse to eat fat, and, as a consequence, the weight of the bacon pig has been fixed at something around 200lbs. live weight. The live weight may be taken as being

20 per cent. above the carcase weight, on the average; and this again may be taken as 20 per cent. above the bacon weight, provided that Wiltshire sides are cured. But it is quite easy to regulate the weight to about 200lbs. live weight, as the pig is the most adaptable of any of the animals on the farm, and it may also be said to be the most profitable, as it increases its weight by one hundredfold or more in six months. The 200lb. pig has the enormous advantage of being just sufficiently supplied with fat, and a fair standard may be taken as 1¼ inches to 1¾ inches of fat down the back. If this proportion is maintained it will be found that the percentage of lean in the meat is just what is wanted by the average customer.

There are, unfortunately, a great many different types of pigs in the United Kingdom. We have some 13 pure breeds, and as time goes on we are threatened with several more, which will add to the confusion of the whole subject of the bacon curer's pig. For, after all, what the bacon curer wants is not any particular breed of pig, but one which will show him properly-balanced fat and lean and a relatively small proportion of bone to flesh. It is quite useless for pig breeders' societies to lay down points for the particular breeds which they fancy, giving rates of value to the tail and the ears, and such features as do not interest the bacon curer at all. The principal part of the pig, so far as the bacon curer is concerned, is the loin and the hams. The public demand is for streaky bacon from the flanks; and some of the breeds of pigs which are much spoken of at the present day are absolutely without this feature. It would, therefore, seem that the time must arrive if we are to make any great progress in pig breeding in the United Kingdom, when the big breeders must try to reduce the number of breeds of pigs instead of trying to add to them, as at present. We have, surely, a sufficient inducement to devote our energies to the proper kind of bacon pig when it is remembered that we in this country spend in overseas countries £1,000,000 per week in bacon, hams, and cognate pig products; and it is quite idle to say that this cannot be altered, as we have in this country every possible condition which would contribute to the development of a large pig industry. We also have many bacon factories where bacon curing is carried on, sometimes with great difficulty, owing to the absence of a proper supply of pigs, notwithstanding the fact that British cured bacon commands the highest price of all the bacon consumed in Great Britain, very often being 20s. per cwt. higher in value than all other imported kinds.

How to obtain this bacon pig is, of course, the principal question, and there are many people who have given a great deal of attention to the subject during recent years. Generally speaking, it may be laid down that the bacon pig can be produced from any of the pure breeds. It is purely a question of selection and feeding. It is also pretty generally accepted that the first cross of some of the pure breeds gives a more satisfactory bacon pig than any other. Thus a cross between a Large Black sire and a Large White sow gives an excellent bacon pig. It very much depends upon the sire, and it is in this particular respect that purity of breed becomes of value. It has been shown by direct experiment that the pure-bred sire will give an increase of 40 per cent. over the stock produced by an ordinary boar; and such a fact goes to prove that the selection of sires is really one of the principal businesses in connection with the production of bacon pigs.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock:—

FEBRUARY 27.—CHARLES S. MYERS, C.B.E., M.D., Sc.D., F.R.S., Director, National Institute of Industrial Psychology, "The Use of Psychological Tests in the Selection of a Vocation." SIR ROBERT BLAIR, LL.D., Education Officer, London County Council, will preside.

MARCH 5.—MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

MARCH 12.—ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.) SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., will preside.

MARCH 19.—R. L. ROBINSON, Member of the Forestry Commission, "The Forests and Supply of North America." LORD LOVAT, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., will preside.

MARCH 26.—NEAL GREEN, "The Fishing Industry and its By-Products." PROFESSOR E. W. MACBRIDE, D.Sc., F.R.S., will preside.

APRIL 2.—SIR LYNDEN MACASSEY, K.B.E., "London Traffic."

APRIL 9.—FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum." PROFESSOR C. VERNON BOYS, F.R.S., will preside.

APRIL 30.—BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "Roads."

MAY 7.—J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation."

MAY 14.—

MAY 19 (Monday).—SIR JAMES FORTESCUE-FLANNERY, Bt., Ex-President, Institution of Marine Engineers, "Marine Internal Combustion Engines." THE RT. HON. LORD BEARSTED will preside.

MAY 21.—PROFESSOR C. VERNON BOYS, F.R.S., "Calorimetry." (Trueman Wood Lecture.)

MAY 28.—MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Date to be hereafter announced :—

T. THORNE BAKER, "Photography in Industry, Science and Medicine."

INDIAN SECTION.

Friday afternoons at 4.30 o'clock :—

MARCH 21.—OTTO ROTHFELD, I.C.S., "Progress of Co-operative Banking in India."

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons at 4.30 o'clock :—

MARCH 4.—THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak." THE RT. HON. LORD BEARSTED will preside.

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

CANTOR LECTURES.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

Syllabus.

LECTURE I.—FEBRUARY 25.—The carbonisation of coal considered as a process for distributing the thermal energy of the coal into therms in the form of gas, tar and coke. Factors which cause wastage of therms in the form of gas and the principles underlying high yields of gaseous therms.

LECTURE II.—MARCH 3.—The inter-relation of therms in the form of gas and tar and the process conditions which affect their distribution. Further principles underlying high yields of gaseous therms. The chemistry and economics of tar cracking.

LECTURE III.—MARCH 10.—The trend of developments in carbonising processes. The de-ashing of coal and other factors tending to increase the value of the therm in the form of coke.

COBB LECTURES.

Monday evenings, at 8 o'clock :—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 25... Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. L. Koch, "Northward of Greenland."

University of London, University College, Gower Street, W.C., 5.30 p.m. Sir Harry Stephen, "Criminal Law." (Lecture I.) At King's College, Strand, W.C., 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture IV.) 5.30 p.m. Dr. R. W. Seton-Watson, "A Survey of Bohemian History." (Lecture IV.)

At the Institution of Civil Engineers, Great George Street, S.W., 5 p.m. Mr. O. C. A. Van Lidth De Jende, "Practical Hydraulic Engineering Problems in connection with Navigation." (Lecture I.)

TUESDAY, FEBRUARY 26... Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6.30 p.m. Mr. H. K. Thomas, "The Fundamentals of Cost Reductions."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Miss Gladys Pott, "Migration of Women within the Empire."

Photographic Society, 35, Russell Square, W.C., 7 p.m. (Kinematograph Group). Papers on the mechanism of the Cine camera, "The Intermittent Motion," "Front Gadgets and Trick Mechanism," "Focusing Devices."

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. L. Rothera, "Electricity as the Motive Power for Ships."

Economics and Political Science, London School of, Houghton Street, W.C., 6 p.m. Sir Edward Grigg, "The Problem of Imperial Organisation."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. J. Barcroft, "The Respiratory Pigments in Animal Life." (Lecture III.)

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m.

(Joint Meeting with the Society of Chemical Industry.) Papers on "The Treatment of Water for Industrial Purposes."

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. J. H. Helwig, "Modern Danish Lyrics, 1870—1920." (Lecture IV.)

5.30 p.m. Mr. N. H. Haynes, "The Roman Empire and its Invaders." (Lecture IV.)

At King's College, Strand, W.C., 5.30 p.m. Sir Bernard Pares, "Russia before Peter the Great to 1861." (Lecture VI.)

5.30 p.m. Dr. H. W. Carr, "The Transition to the Relativist Conception of Nature." (Lecture IV.)

At the London School of Economics, Houghton Street, W.C., 5 p.m. Prof. A. P. Brigham, "The Geography of the United States, Regional and National." (Lecture II.)

WEDNESDAY, FEBRUARY 27 ... London County Council, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Sir Napier Shaw, "An Introduction to Modern Meteorology." (Lecture I.)

Literature, Royal Society of, 9, Bloomsbury Square, W.C., 5 p.m.

Brewing, Institute of (Midland Counties' Section), Burton-on-Trent. Prof. H. E. Armstrong, "Humour and its Potency,—a Character Study."

British Academy, at the Royal Society, Burlington House, Piccadilly, W., 5 p.m. Dr. J. W. Mackail, "Bentley's Milton." (Warton Lecture on English Poetry.)

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. H. G. Williams, "Foreign Exchange, its Effects on Industry and Cost of Living."

Microscopical Society, 20, Hanover Square, W., 7 p.m. (Section in the Industrial Application of the Microscope.) 1. Mr. R. Daubney, "Notes on some Parasitic Worms of Importance to Agriculturists." 2. Mr. H. J. Denham, "Practical Microscopy in Research on Textile Fibres." 3. Mr. J. E. Barnard, "Technical Microscopy."

Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Mr. W. B. Wright, "Age and Origin of the Lough Neagh Clays."

Japan Society, Victoria and Albert Museum, South Kensington, S.W., 3 p.m. Lieut.-Colonel E. F. Strange, "The Incense Ceremony."

Automobile Engineers, Institution of, 244, Deansgate, Manchester, 6.30 p.m. Mr. P. Pritchard, "Modern Foundry Practice."

University of London, University College, Gower Street, W.C., 3 p.m. Prof. E. G. Gardner, "Problems of the Inferno." (Lecture VI.)

5.30 p.m. Prof. Geyl, "English Diplomacy in Holland in the XVIII. Century." (Lecture III.)

5.30 p.m. Mr. I. C. Grøndahl, "Contemporary Norwegian Literature." (Lecture IV.)

5.30 p.m. Mr. R. A. Peddie, "Printing Presses and Machinery from the Earliest Times and their Influence on the Book and Newspaper."

6 p.m. Prof. Karl Pearson, "The Current Work of the Biometric and Eugenics Laboratories." (Lecture III.)

At King's College, Strand, W.C., 5.30 p.m. Mr. B. Rackham, "The Artistic Background of Mediæval History—Glass and Pottery."

At the Royal College of Music, South Kensington, S.W., 5 p.m. Sir Henry Hadow, "English Composers of the Tudor Period." (Lecture I.)

At the Institution of Civil Engineers, Great George Street, S.W., 5 p.m. Mr. O. C. A. Van Lidth de Jende, "Practical Hydraulic Engineering Problems in connection with Navigation." (Lecture II.)

THURSDAY, FEBRUARY 28 ... Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6.30 p.m. Mr. A. E. Cooper, "The Requirements of Motor Delivery Vans."

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

British Decorators, Institute of, Painters Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. A. Orr, "A Tour in Spain with the Incorporated Institute of British Decorators."

Auctioneers and Estate Agents Institute, 34, Russell Square, W.C., 7.30 p.m. Mr. W. S. Edgson, "The Valuation of Shop Property."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Mr. A. S. Fitzgerald, "The Design of Apparatus for the Protection of Alternating Current Circuits."

London County Council, Geffrye Museum, Kingsland Road, E., 7.30 p.m. Mr. H. A. Tipping, "Furniture—The Dining Room from the Earliest Times to the Present Day." (Part II.)

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. Sir W. Bragg, "Crystalline Structure of Organic Substances." (Lecture IV.)

Mechanical Engineers, Institution of (North-Western Branch), Engineers Club, Manchester, 7 p.m. Mr. J. E. Hurst, "Engineers' Inventions and Patents."

University of London, University College, Gower Street, W.C., 5.30 p.m. Signor C. Pellizzi, "Campanella."

5.30 p.m. Mr. L. Björkhagen, "Modern Swedish Prose Authors." (Lecture IV.)

5.15 p.m. Prof. J. E. G. de Montmorency, "Comparative Law of Europe and Asia." (Lecture VI.)

At King's College, Strand, W.C., 5.30 p.m. Dr. A. R. Pastor, "Spanish Mysticism." (Lecture I.)

5.30 p.m. Prince D. S. Mirsky, "The History of Russian Literature." (Lecture VI.)

At St. Mary's Hospital Medical School, Praed Street, W., 5 p.m. Prof. B. J. Collingwood, "Blood." (Lecture II.)

At St. Thomas's Hospital, Albert Embankment, S.E., 5 p.m. Dr. J. A. Murray, "Cancer." (Lecture II.)

At the London School of Economics, Houghton Street, W.C., 5 p.m. Dr. J. H. Clapham, "Britain on the Eve of the Railway Age." (Lecture II.)

FRIDAY, FEBRUARY 29 ... Royal Institution, Albemarle Street, W., 9 p.m.

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. T. A. Scotton, "The Making of a Railroad Locomotive."

Auctioneers and Estate Agents Institute, 34, Russell Square, W.C., 11.30 a.m. Conference of Agricultural Members. 2.30 p.m. Mr. A. W. Merry, "Practice under the Agricultural Holdings Act, 1923, in the light of recent Legal Decisions."

University of London, King's College, Strand, W.C., 5.30 p.m. Prof. R. W. Seton-Watson, "The Rise of Nationality in the Balkans." (Lecture VI.)

5.30 p.m. Dr. H. Lamb, "The Internal Constitution of the Earth." (Lecture III.)

At the London School of Economics, Houghton Street, W.C., 5 p.m. Prof. A. P. Brigham, "The Geography of the United States, Regional and National." (Lecture III.)

At the Institution of Civil Engineers, Great George Street, S.W., 5 p.m. Mr. O. C. A. Van Lidth de Jende, "Practical Hydraulic Engineering Problems in connection with Navigation." (Lecture III.)

SATURDAY, MARCH 1 ... Royal Institution, Albemarle Street, W., 3 p.m. Mr. W. De La Mare, "Character in Fiction."

London County Council, Horniman Museum, Forest Hill, S.E., 3.30 p.m. Mr. H. N. Milligan, "Animals which live in Trees."

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FRIDAY, FEBRUARY 29, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 3rd, at 8 p.m. (Cantor Lecture.) EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." (Lecture II.)

The Lecture will be illustrated with a cinematograph film showing the decomposition of cyclohexane by heat.

TUESDAY, MARCH 4th, at 4.30 p.m. (Dominions and Colonies Section.) THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak." THE RT. HON. LORD BEARSTED will preside.

WEDNESDAY, MARCH 5th, at 8 p.m. (Ordinary meeting.) MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 20th, 1924; SIR STANLEY BOIS, late Chairman of the Ceylon Chamber of Commerce, in the Chair.

The following candidate was proposed for election as a Fellow of the Society :—

Bone, Stephen, London.

The following candidates were duly elected Fellows of the Society :—

Elston, Frederic, London.
Mant, Sir Reginald Arthur, K.C.I.E., C.S.I., London.
Smith, Frederick Richard, Hampden-in-Arden.
Young, Brig.-General Henry Alfred, C.I.E., C.B.E., Exmouth.

A paper on "New Uses for Rubber" was read by MR. PERCIVAL JAMES BURGESS, M.A., F.I.C., Chairman, Rubber Growers' Association.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, FEBRUARY 5TH, 1924.

SIR GEORGE R. LE HUNTE, G.C.M.G., formerly Lieut.-Governor of British New Guinea, in the Chair.

THE CHAIRMAN, in opening the meeting, said he regretted very much that owing to the time of the meeting he would have to leave before the end, to catch his train. He wished to express his great pleasure at meeting his old friend the lecturer, Mr. Walker, whom he had known so well in New Guinea on the staff of the London Missionary Society. He knew of Mr. Walker's good work. He had had the opportunity of reading a draft of the paper, and he thoroughly agreed with what Mr. Walker said in it with reference to the native races generally and with regard to New Guinea in particular.

The paper read was :—

THE COMMERCIAL FUTURE OF THE BACKWARD RACES.

By F. W. WALKER,

Managing Director of the Papuan Industries, Ltd.

I am grateful to the Royal Society of Arts for giving me the opportunity of addressing you on this subject, which is one of great and growing importance to the British Empire.

I am especially grateful to Sir George Le Hunte for consenting to preside on this occasion. It is one more proof of his deep and abiding interest in the welfare of native races, of which he has given many during his long and distinguished career. The British Empire owes much to such men as he, who have maintained our honour and upheld our high traditions in positions

of great responsibility in the remote parts of the Empire.

I was in New Guinea during the whole of Sir George's term of office as Lieutenant-Governor so I can speak from first-hand knowledge, and I can assure you, and I can assure him, that he is remembered with deep gratitude by all those who have the interest of the natives at heart.

British New Guinea, or to be strictly correct, British Papua, which first became a Crown Colony in 1888, and was handed over to the Commonwealth of Australia in 1906, has been particularly fortunate in its Governors. It must not be confused with what was formerly German New Guinea, which is quite a separate territory and has a Governor of its own with head-quarters at Rabaul in New Britain.

The first Governor of British Papua was Sir William MacGregor, who was an exceptional man in every way. By him the foundations of the Constitution were well and truly laid with great wisdom and foresight. I think I am correct in saying that for the first time in the history of the British Empire, the sale of drink and firearms to natives was prohibited from the start, under heavy penalties, and these laws have been strictly and successfully enforced right up to the present day, with incalculable benefit to the natives, as Sir George can testify.

The present Governor, the Hon. J. H. P. Murray, a brother of Prof. Gilbert Murray, is not one whit behind his great predecessors in his regard for and interest in the welfare and progress of the natives, and if he is spared to carry out his ideas, of which I shall have more to say later on, he will confer an immense and enduring benefit upon Papua.

Favoured with such a striking succession of great pro-consuls as the late Sir William MacGregor, Sir George Ruthven Le Hunte, and the Hon. J. H. P. Murray, and with the two great curses of native races, drink and firearms, excluded, the outlook for the natives of Papua is surely a hopeful one, provided men of like spirit can be found to carry on this great succession.

In order to secure this very desirable result it is necessary that public opinion at Home should be educated and informed, so that men of this high type shall be adequately supported in their great endeavours to uplift these primitive peoples.

THREE POLICIES.

Canon Elliott, of Leicester, speaking last year at the London Rotary Club, said:—"The first policy of the white man with regard to the Backward Races was to exterminate them, the second policy has been to exploit them; now it is to be hoped that we are going to recognise that the wisest and best policy of all is to uplift and help them."

This last policy needs widespread public support if it is to be effectively carried out. It is on behalf of this policy that I wish to plead to-night. The question we have to consider is, how are we to secure a future of progress and usefulness for the Backward Races? What policy must we adopt with regard to them which is in their best interests—because that is the policy which is in the best interest of the British Empire and also of the world in general.

A great responsibility rests upon us in this connexion, as we have more of these Backward Races under our care than any other Empire that has ever existed, and it is impossible to exaggerate the importance of a right policy with regard to them.

A PROBLEM IN ECONOMICS AND ETHICS.

This is essentially a problem in Economics, but because the prime factors in the case are men and not machines or inanimate matter, it is a problem which cannot be successfully solved apart from Ethics. That type of Political Economy which ignores the human element has been utterly discredited by the experience and progress of modern times. The evidence of this is seen in the rapid spread of various welfare movements and in the success of numerous schemes of co-partnership and profit-sharing and similar developments of recent years. Whatever our views may be with regard to these developments, they are a clear indication of the recognition of the fact that ethical considerations can no longer be ignored if the wheels of industry are to run smoothly, and while this is the case here in England it applies with equal force to industrial developments abroad. The mere fact that in the one case the labour is white and in the other case it is black, does not make any essential difference. In both cases the labour is human and the principles involved are the same. In a word, the demand for justice cannot be admitted in the case of the white man and denied in the case of the coloured man.

DANGER OF COLOUR PREJUDICE.

The study of history clearly reveals that "There is a Power, not ourselves, which makes for righteousness," and if we are not prepared as an Empire to be scrupulously just and impartial in the shaping of our policy with regard to the subject races committed to our care, retribution will surely fall upon us, as it has fallen upon other Empires which made a wrong use of their power. The "mills of God grind slowly," but iniquity cannot escape their grinding, however long it may be deferred. Those who refer to the coloured races with contempt as "niggers" and sneer at any suggestion to secure for them a fair opportunity for development and progress are the most dangerous enemies of the British Empire, for they are "enemies within the gate." The enemies outside we have always been able to deal with successfully, but these enemies in our midst constitute a more insidious danger, and I for one regard them with no small anxiety, for they are financially strong and powerful, and unless the great spirit of the nation asserts itself they will work their will upon these Backward Races with disastrous results to all concerned.

Without sympathy and understanding it is impossible for men, white or black, to pull together. If these elements are not cultivated, war, with all its waste and misery, is inevitable.

Basil Mathews brings this point out very clearly in his foreword to a pamphlet by Harold Begbie on "Christianity and Commerce," recently published.

Mr. Mathews writes :—

"'The black will never understand the white, nor the white the black, as long as black is black and white is white,' argues Captain Woodward, the South Sea labour recruiter, one of Jack London's heroes in his 'South Sea Tales.' The talk is going on in the parlour of the 'pub' at Apia, the greatest harbour of the Samoan Islands.

"A friend retorts vigorously: 'If the white man would lay himself out a bit to understand the workings of the black man's mind most of the messes would be avoided.'

"This provokes Captain Woodward, who thereupon breaks out into a long, vehement reply, in which he says: 'Don't talk to me about understanding the nigger. *The white man's mission is to farm the world, and it's a big enough job cut out for him. What time has he got left to understand niggers, anyway?*'

"And the worthy captain follows his moral with a story of labour-recruiting, which issues in a murderous attack by recruited natives, followed by a cold blooded massacre by a white man with two rifles and inexhaustible ammunition.

* * *

"That conversation and that story sum up in one picture the tragic, dramatic contest of those two ideas of exploitation on the one hand and understanding on the other—not only in the South Seas, but in the whole world wherever the white man has come into contact with 'the backward races.'

"The story during the last four centuries of the white man's expansion into America, India, Africa, Australasia, and Polynesia, indeed, has proved that—for that period of human history, at any rate—it has been 'the white man's mission to farm the world.' And in his indomitable and often ruthless will to 'farm the world' the white man has often, on the one hand, mown down the races that opposed him, and, on the other, yoked to his service those who did not. The dying out of the Red Indian, the growth of the African slave trade with America, the extermination of the Tasmanians, the foul record of the Kanaka traffic in the South Pacific, are all part of a story of infamous wrong that—in total—represents the blackest stain on the world record of the white races."

We may admit the truth of these words but some may be disposed to comfort themselves with the thought that these things belong to a past age.

Do not let us live in a "fool's paradise." All unscrupulous and ruthless white men are not dead. They are perhaps a little more discreet in these days, more careful not to "give themselves away," but they are still amongst us in considerable force watching for opportunities, and to them the ignorant and defenceless "nigger" dwelling in lands of great wealth and future possibilities is "fair game." If you suggest that the said "nigger" should be enlightened and taught and assisted to develop his own land for his own benefit they are immediately up in arms and accuse you of "spoiling" these people and from their point of view such a policy will undoubtedly "spoil" them. Many good people living quietly at home in England have

little idea of what is going on in many of these tropical lands at the present day. If any persons want information on these points let them apply to the Anti-Slavery and Aborigines Protection Society, whose records contain much startling evidence of the need for constant watchfulness in connexion with these matters.

Quite recently that Society brought to light two cases where natives were flogged to death by white planters in different parts of Africa, the one in Kenya and the other in Rhodesia, less than a year ago.

I quote these cases to show that we have still this kind of white man in our midst, and, unfortunately, he is not as rare as many suppose.

IMPORTANT WORK OF THE ANTI-SLAVERY SOCIETY.

In passing, permit me to say we have every reason to be grateful to a Society which keeps a watchful eye on this type of Britisher. Many people seem to imagine that the work of the Anti-Slavery Society was practically completed when slavery was abolished in 1836, but that is a great mistake. The full title of the Society is "The Anti-Slavery and Aborigines Protection Society," and their splendid work in connexion with the Congo and Putumayo atrocities, only to mention two great instances, is evidence of the great need of their activities in later times. A more recent and no less striking instance of their usefulness is in connexion with the question of slavery in Abyssinia, which still exists there almost unnoticed, on an immense scale. But apart altogether from these great outstanding instances of their usefulness, the very existence of the Society is a constant check on the ill-treatment of natives, and all who are interested in the future of the Backward Races ought to give this great Society their hearty and practical support.

We must face the fact that there is still an element in our midst which is not in sympathy with native aspirations, and even though in only a few cases does this lack of sympathy show itself in a brutal form, it has to be reckoned with as a distinct danger to the successful solution of the great problem of native advancement and welfare.

THE HON. J. H. P. MURRAY ON COLOUR PREJUDICE.

The Hon. J. H. P. Murray, in a paper which he read before the Royal Anthropological Society on May 15th of last year, when he paid a brief visit to England, made some very significant remarks in this connexion. He said :—

"The average white man is often so masterful, and may I add, occasionally so utterly devoid of any idea of courtesy, that he will ride rough-shod over the feelings of the native—for, he will unconsciously argue, a black man has no right to have any feelings at all. I think that this is the attitude that we are all inclined to take up instinctively when we are first brought into contact with the coloured races, and I think further that a strong effort of will and reasoning power is necessary if we are to overcome it. Even as late as 1900 a book was published in America to prove that the Negro was not a man but a beast, created for the service of the white man. Such a crude philosophy shocks us to-day when expressed in this bald unqualified manner; for, though we may not always be quite sincere when we talk of the duty of protecting the 'inferior races,' and when we say that their interests are 'a sacred trust,' still we have at any rate, the grace to assume a virtue even if we do not possess it, and at least to pretend that in all administrative action the interests of the natives must come first. Not that I would suggest for a moment that it is all a pretence. The theory of the priority of native interests has been called a 'truism' by Sir Frederick Lugard, and doubtless for many years it was so regarded by English writers on the subject, and probably the theory has even been carried into practice by the majority of Crown Colony Governors. But I cannot help thinking that during the last few years there has been a reaction against this view of administration, and that there is a growing tendency to regard the native and his lands as the spoils of the conquering and superior race, to be exploited by the members of that race primarily for their own benefit. I do not mean that you will find writers who have the courage to put their views in this plain and unvarnished language, for, so far as I know, all still pay lip service to the 'truism' of Sir Frederick Lugard; but in actual administration, I fancy that the importance of native interests looms less large at the present time than it did before the War."

"Few, if any nowadays, in English-speaking countries at any rate, would go so far as to deny the existence of this respon-

sibility towards the natives, but many would in fact, though not perhaps in word, subordinate it to other objects. For instance, if some scheme for the development of a territory promised favourable results from a financial point of view, but was likely to prejudice the best interests of the native inhabitants, I think that you would find that a majority of people would be in favour of going on with the scheme; though they would pay the theory of responsibility the compliment of trying to make out that the natives would not suffer so much after all. In the jargon of the present-day psychology the old idea of treating races not as human beings but as a means to an end, still exists in the unconscious and not infrequently succeeds in emerging therefrom and in expressing itself in action."

These are serious statements by one who is thoroughly competent to speak on these matters. As I have already said, it is no use living in a "fool's paradise." We must recognise the fact that there are numbers of people who still tenaciously cling to the idea that the world was made for the dominance of the white race, and they are not prepared to give any adequate recognition to the rights of the coloured races in any broad and generous spirit. Those who hold these views are not all brutal and selfish people by any means. If they were, it would be an easy matter to deal with them, but there are many amongst them, who are perfectly respectable and conscientious people who honestly believe that the policy which makes the Backward Races the servants of the white man, is not prejudicial to their true interests, just as at one time many good people defended slavery in the same way and on the same grounds. These are the people whom it is urgently necessary to convince. The weight of evidence is against them and it is of vital importance that the widest publicity should be given to this evidence. The progress of the British Empire and the progress of the world does not and cannot mean the advantage and progress of a favoured few. The mere fact that the coloured races number two-thirds of the human race is enough in itself to discredit colour prejudice and colour distinctions as a bar to the onward march of humanity. Is it rational to suppose that merely because races inhabiting the tropics develop a dark pigment in their skins, they are on this account intellectually and morally incapable of rising in the scale of civilisation, and that they should for this reason be permanently disqualified from cultivating their lands and developing the wealth of those lands for their own benefit? Such a notion will not bear the light of intelligent consideration for a single moment. An Empire that attempts to arrest the progress and development of these many millions of her people and make of them "hewers of wood and drawers of water" for all time, is doomed to fall to pieces sooner or later. This is a question of life and death for us as well as for the coloured races, and it will be well if we see this before it is too late. How long will the coloured races of the world submit to such injustice? The opportunity for development is not the exclusive right of the white man. If we believe in the great destiny of the human race we must believe in the coloured man, because he constitutes by far the greater part of it, and he certainly will not be content to remain in a position of permanent subjection, nor ought we to wish it. There are already mutterings of discontent and stirrings of new life in this dark mass of humanity, which are the early symptoms of coming trouble if our statesmen do not learn in time to meet these demands for freedom and opportunity for development which have been too long denied to them.

Dr. Du Bois on What the Dark World is Thinking.

Dr. Du Bois, the leader of the Pan-African Movement, says in his book "Dark Waters":

"What then is this dark world thinking? It is thinking that wild and awful as the Great War was, it is nothing to compare with the fight for freedom which black and brown and yellow men must and will make unless their oppression and humiliation and insult at the hands of the white world cease. The dark world is going to submit to its present treatment just as long as it must and not one moment longer."

It is only fair to Dr. Du Bois to say that he himself does not recommend any resort to violent measures. I had the privilege of being present at several meetings presided over by him when the Pan-African Conference was held in London last year, and I was much impressed by the wisdom and moderation of the speeches which were made, but Dr. Du Bois very wisely warns us what "this dark world is thinking," and

it is well that we should take note of what he says. They have not the control of arms or ammunition at present, but France is training a huge army of black troops which, if a collision between the black and the white races does occur, may seriously increase our difficulties in years to come. The moral of all this is, avoid the possibility of collision by adopting a "right policy."

Mr. Basil Mathews, in that same foreword from which I have already quoted, says :—

"The rise all over the world of vigorous and often revolutionary race movements has made this whole issue of the relation of the white races to the backward peoples. . . . the central problem of world politics for the twentieth century."

The Hon. Sir Arthur Lawley on the Vital Importance of this Problem.

The Hon. Sir Arthur Lawley, presiding at a meeting of the Royal Colonial Institute early this year when the subject under discussion was "The Problem of the African Native," said :—

"Transcending every other problem in Africa to-day is the question how far European civilisation is going to affect the natives, many of whom are intelligent and capable. They claim the right to share in the privileges of civilisation, and the question is, what are we to do with these people ? They cannot be ignored; they are contributing year by year more and more to the national wealth, showing their capacity and their aspiration to rise in the social scale. They may become an element of great good if properly handled; or, on the other hand, they may become a potential menace to the whole of Africa. I believe that when the men who guide the destinies of Africa deal with the question —and the sooner the better—it should be done in a spirit of generosity, sympathy, and statesmanship."

A policy which will drive these millions of our fellow creatures to desperation is obviously a peril of the first order to the British Empire, and in order to avoid this peril we must endeavour to find a safe and sufficient outlet for this mass of new life which is rapidly asserting itself and mingling its activities with the great civilised order of the world. This is the day of our opportunity. To-morrow it may be too late.

There is a tide in the affairs of men,
Which, taken at the flood, leads on to fortune;
Omitted, all the voyage of their life
Is bound in shallows and in miseries.

The Two Most Pressing Demands for Great Britain.

The two most pressing demands for Great Britain at the present moment are raw materials and markets.

With regard to raw materials, the bulk of these come from the tropics and we are entirely dependent upon the coloured races to produce them. The white man never has done and never can do the manual labour of the tropics. It is a matter of vital importance to Great Britain to discover a method of developing the tropics under which we can secure the maximum production. The system under which we can get the most raw material for our factories is the system we want. The crux of this problem is obvously the "willing worker" because only with the "willing worker," can we expect to get the best results.

Mr. J. H. Harris, M.P., on the "Willing Worker."

This point is very clearly brought out by Mr. J. H. Harris, M.P., in an article which appeared in the "Manchester Guardian" of November 27th last year, under the title "Cotton Growing in Uganda. Native Producer versus White Control."

He says that the total value of the cotton in Uganda for the whole of 1923 will probably exceed £2,000,000. Less than fifteen years ago it was only £20,000. This astounding achievement is the result of the natives working as free and independent men, cultivating their small holdings with the help of their wives and families.

The Settlers' organ of the neighbouring Colony of Kenya makes an attack on this policy and asserts that it is "wasteful." They say that from 1,000,000 to 1,500,000 out of a population of 3,000,000 were employed in producing this crop, and that under European supervision, scientifically controlled, £5,000,000 worth of cotton would have been produced with the same amount of labour, instead of merely £2,000,000 worth. This contention is based upon the assumption that the 1,500,000 workers would have been available as wage earners and that they would have worked as cheerfully and effectively under the white man as they would have done for themselves. Taking the average family as five the 1,500,000 workers would include only 300,000 men and it is not conceivable that all of these, or anything approaching that

number, would have been willing to leave their homes and work under a white man for wages. The striking and important thing about this amazing outburst of production is the fact that it is the direct result of the encouragement of independent native labour, and if we add to this the not less astonishing achievement in connexion with cocoa growing in Nigeria and the Gold Coast, we have a very strong case in support of this policy. As Mr. Harris points out, "the vital factor is the willing worker," without whom nothing can be accomplished. When once the native is fired with the producing spirit, there is hardly any limit to his power to produce. No system which fails to evolve the willing worker can, in the final issue, be regarded as economically sound, because it cannot give all-round satisfactory results, and sooner or later it is bound to break down altogether.

The Two Competing Systems Compared.

Let us examine the two great competing systems for the development of the tropics in the light of this test.

1. Development by means of big plantations owned by the white man.

2. Development by means of native peasant proprietors, working on small holdings, with the help of their wives and children.

Taking the big plantation system at its best, because it is only right to recognise that while this system undoubtedly lends itself to great abuses, which is one argument against it, it would not be fair to condemn it on the ground of these abuses alone; and, looking at it apart altogether from the questions of tyranny and brutal outrage, which so often are found in connexion with it, there are three serious objections which are inherent to it even in its best forms.

Under this system: 1. The natives, speaking generally, are deprived of their land, and a people who sell their land sell their independence, often literally, for a mere "mess of pottage." 2. The home life of the people is broken up because the men are taken away from their wives and families to great distances, and often for long periods. No system which breaks up the home life of a people can be a good one. 3. They are herded together in great compounds under unnatural conditions, which often lead to abnormal forms of vice, especially when they remain for long periods.

Contrast with this the opposite system, where the native cultivates his own land for his own benefit with the help of his wife and family. Under this system he is 1. A free man. 2. The home and village life is strengthened because every member of the family is a helper in the work. 3. The man is living a natural and healthy life surrounded by his wife and family.

Which of these systems is most likely to produce the "willing worker," and which system is likely to result in a happy, contented and progressive people? There can be no doubt about the answer, and the facts on the Gold Coast, in Nigeria and Uganda, and other places, are overwhelmingly in favour of development on independent lines.

Governor Murray, in the paper from which I have already quoted, says:

"It is obvious that the native must work, but the question is, how are you going to induce him to work? You can force him to work for the benefit of a white employer, either directly (to which great objection would be raised) or indirectly, by means of a tax (which is permissible), or you can compel him to work for his own benefit, as we are doing in Papua. The latter is, in my opinion, the only really effective way of dealing with the question. To compel a native to work in the interests of a white man certainly has an unpleasant appearance, and has been distinctly disapproved by the League of Nations, and, furthermore, it leads to nothing. He has learned to chop, scrub, and pick weeds, but it is quite possible that he may have learned little else. And if we are going to keep him till the end of time as an unskilled labourer working for the white man at a wage of 2s. 6d. a week, I do not think he will have much to thank us for. Instead of keeping the native indefinitely as a servant of the white man we must induce him to strike out for himself, with plantations and other industries of his own."

The Importance of Native Agriculture.

Later on in the same paper Governor Murray says:—

"Native agriculture is important as tending to conserve and stabilise the native race and to prevent the native from losing his individuality and from sinking down into the position of a tenth-rate white man, aping the lower and more contemptible

aspects of the white man's culture, but unable to recognise or appreciate the higher. Native agriculture in Africa has been recommended by high authorities as superior to any other in rapidity of expansion and general efficiency. I have but little hope that I shall ever be able to say the same thing of Papua, though my successors may; but even if Papuan agriculture is never to be efficient I should still regard its encouragement as all important on moral grounds, as saving the race from disintegration."

Sir Frederick Lugard on Character Results of Independent Labour.

The effect of the system of independent labour on character development is an important consideration. Sir Frederick Lugard, who is perhaps the greatest living authority on native questions, published in 1922 a very important work, entitled "The Dual Mandate in British Tropical Africa," which is a perfect compendium of information on this great problem.

On page 294 of that work he says:—"Cecil Rhodes was an ardent believer in the efficacy of individual small holdings as an aid to self-respect." And he himself says on the same page:—"I believe that there is nothing which can so effectively tend to eradicate the servile habit of mind in a people who have for generations been accustomed to regard themselves as slaves or serfs, as the sense of responsibility of the free occupier of the land." On page 295 he says:—"The labourer who works on land which is not his own, whether as the serf, or even as the paid servant of an estate owner, has little interest in its improvement during, and none beyond, his own lifetime. Individual proprietorship is no doubt inimical to the supply of wage labour for large estates, but it makes for individual progress, thrift, and character. It is the strongest inducement to good farming, and politically an asset to the Government." He adds that the French verdict is the same. They report after careful enquiry:— "The system of individual ownership is incontestably the one which is most favourable to production."

These are weighty opinions which cannot safely be disregarded. In addition to the fact that a system of independent labour develops initiative, calls out energy and awakens ambition, all of which are tremendous factors in the worker, calculated to secure the maximum of production, there is another great fact which we cannot afford to ignore. Primitive peoples, and especially the African, who far out-numbers all the other primitive races in the world, do not take kindly to working for a master for wages. Such a man loves his own little patch of ground around or near his own home and would rather be poor, under such congenial conditions, than rich, working for wages away from home. If, in shaping a policy for his future development, we do not take this into account, we are doomed to failure from the start.

The advocates of the big plantation policy say: "We will give him a little plot of land near our plantation and let him bring his family and make his home with us"; but this does not meet the case. What will happen if the plantation company collapses, and a considerable percentage do collapse. The bottom immediately falls out of the native world and they are immediately plunged into a state of helpless misery and distress. It is not a sufficiently broad and stable foundation upon which to build a future of progress and prosperity.

In this connexion Governor Murray says, speaking of the future of the Papuan native under Australian rule:— "There are many dangers in his path, and the greatest danger of all may come from what I may call a benevolent capitalism—a capitalism which will use the native solely as a means towards the development of the country in the interests of non-resident capitalists, to the disregard of the future of the native race as a whole and its eventual advancement to a higher grade of civilisation. Such a capitalism disguises itself by an excessive and scrupulous care for the health of the native, for their education, especially their technical training, and even occasionally by zeal for the proper feeding and accommodation of the indentured labourer, and it is possible that, in this guise, it may so far impose upon the Australian public and the Commonwealth Government as to persuade them to allow it to control the administration of Papua, and if so, the doom of the Papuan is sealed—*he will remain a servant till the end of time.* If, however, he escapes this fate, he may have a fairly prosperous future before him, and I for one shall be much surprised if eventually he does not show himself a better man than his cousin the Malay."

No One System Altogether Good, but Independent Labour Promises Best Results.

I am not an extremist. Truth is seldom if ever found in extremes. I do not wish to suggest that development in the tropics by means of plantations owned by white men is altogether bad, or that development by natives working on independent lines is always and altogether good. Each system has its drawbacks and its advantages, and perhaps the best results will be achieved by a happy combination of the two with a very large preference for the independent native proprietor. Sir Frederick Lugard, in the book from which I have already quoted, says: "Plantations of limited area owned by Europeans are useful as object lessons to natives to improve their methods." Governor Murray, notwithstanding his strong predilection for the native peasant proprietor, is also of this opinion. It is all a question of degree. If the big plantations dominate the country and stand in the way of all independent native development they become an undoubted evil, but, as Sir Frederick Lugard says, if they are of "limited area" they may prove beneficial in many ways. For the young unmarried men they are a means of discipline and training in industry which is all to the good, but it is not good for the plantations to be too large, or for the period of indenture to be too long. What is wanted is the individual white planter of the right sort, rather than the huge company with capital running into millions, because the financial necessities of such big concerns compel them to do everything on a large scale and the individuality of the native is threatened by the vastness of the operations. He learns less, because he does one thing continuously instead of having a variety of work, as would be the case on a smaller plantation. Moreover, these enormous companies make too big a demand both for land and labour to be good for native developments in the country.

From the economic point of view the most serious objection to development by means of big companies as against the native peasant proprietor is that in their case all the net profits are sent to non-resident shareholders, and this constitutes a steady drain upon the wealth of the country which permanently impoverishes it.

On the other hand, under the system of development by means of native peasant proprietors, the profits on the produce remain in the country in the hands of the natives, and having the means to purchase, and the constantly increasing desire to possess the goods which England supplies, markets are opened up for us under this system which would be practically or comparatively non-existent under the opposite system. This is an extremely important point and should be given due weight.

If, then, as we have seen, by means of the native producer: (1) The maximum of raw material can be obtained, and (2) Markets can be opened up for British manufactured articles which otherwise would not be secured, it is clear that this policy is one which should be encouraged to the utmost in the interest of Great Britain.

So far as the future of the natives is concerned, it is equally clear that this policy is in their interest, indeed it may be said to be the only policy which offers them any prospect worth calling a future at all.

How This Policy can be Best Promoted.

It only remains for us to consider now how best this policy can be promoted and applied to the Backward Races in the various parts of the British Empire in order to secure for them the full benefit of it, and this brings me to the suggestion that here we have a great new field of opportunity for the missionary enthusiasm of the churches. The native producer needs guiding, and in many cases he requires financial assistance in order to get him started on this new path of industry. Upon whom does the responsibility rest of giving him the help he needs at this critical stage? Many will at once reply, "Upon the Government," and while I agree with this reply I would add, "and upon the Christian Church."

Both have a common and admitted responsibility for the future of the Backward Races, and both should mutually co-operate in the endeavour to organise the industry of the natives on sound progressive lines for their own benefit.

A New Field of Service for Missionary Enterprise, Co-operating with Governments.

This is a great opportunity for the laymen of the churches, as it calls for their special knowledge and experience and for their powers of commercial organisation and control. This would necessitate the creation of a new type of missionary society, as

the existing societies are not suitably constituted to undertake commercial responsibilities on a large scale, nor would it be advisable for them to attempt it, for many reasons. The funds for this purpose should be raised by means of loans or shares at a fixed low rate of interest, say 5 per cent., and all the profits after the payment of this interest should go to the natives who produce them, to finance their social, intellectual and spiritual progress and improvement. The work should be done on sound business lines, as nothing would be gained by pauperising and coddling the natives. Every effort should be made to work in close co-operation with the Government. The members of the staff, should be paid on the same basis as medical and other missionaries, because only in this way would the right type of man be secured. This work would call for genuine sympathy and a deep and sincere interest in the welfare of the natives. The great service which the churches could render would be by finding such men and sending them out. The churches have sent out Evangelical missionaries, educational missionaries, women mis ionaries, and medical missionaries, each of whom are doing their special work very effectively, but we have yet to see, on any appreciable scale, the business missionaries, who, on the same terms and in the same spirit as these other types, will devote themselves to this great task of helping the Backward Races to learn the duty of work as well as of worship, and to protect them from unscrupulous exploitation. Such organisations as I have outlined, entirely managed and controlled by Christian business men, would immensely strengthen every existing form of missionary work without in any way interfering with the work of founding or controlling native churches, as this can very well be left to the clerical missionary. They should also prove to be very helpful agencies in assisting the various Governments concerned.

The Papuan Industries, Ltd. A New Organisation of this Type.

The Papuan Industries, Ltd., with which I am connected, is a missionary organisation of this kind. It has now been at work in the Torres Straits and in British Papua for a little over seventeen years with results which are a striking proof of what can be done on these new lines. It is only a small enterprise, working on quite an insignificant scale, but just as in the laboratory, experiments with small quantities can conclusively demonstrate possibil.ties on an unlimited scale, so I claim that we have proved conclusively the value and possibility of this new type of organisation, though, owing to losses due to the War, we have not yet attained commercial success.

With your permission I will conclude my paper by giving a brief account of the origin of this enterprise and what it has already achieved.

Some years before the Papuan Industries, Ltd., was started, when I was a missionary of the London Missionary Society, I came across some natives on one of the islands of the Torres Straits in a pitiable state of starvation and misery. Instead of applying to the Government for relief, which was the usual thing to do under such circumstances, I offered to buy a boat for them out of my own money, and give them a chance to work, and thus enable them to provide for themselves and their wives and families, instead of always depending upon the Government for doles of food. They very eagerly accepted my offer, and worked with such energy that within eighteen months they not only provided for their own requirements, but they paid off the whole cost of the boat.

The late Hon. John Douglas, C.M.G., a former Premier of Queensland, who held the office of Government Resident for the North at the time, was so pleased with this experiment in self-support, that he arranged for the whole of the business transactions in connexion with the working of this boat to be dealt with through his office. When it proved to be such a great success, he started other boats, and when the Papuan Industries, Ltd., arrived on the scene some years later, conditions were ripe for further developments. Owing to our opportune arrival, the work soon went ahead and a rapid increase in the number of boats quickly took place, the Government and the Papuan Industries, Ltd., finding the necessary capital in equal proportions. At the present time there is a fleet of twenty-six native owned boats at work, of an average value of £400 per boat, making a total value of over £10,000 for the fleet, *all of which is owned and has been paid for by the natives out of their own earnings.*

The total value of the produce collected by these boats in one year, viz., in 1921, as

certified by the Government's Auditor, amounted to over £16,000.

Until quite recently all the Eastern Island boats went to Thursday Island to the Government, and all the Western Island boats came to us at Badu. In July, 1922, the Government, after careful investigation, decided that it would be advantageous to the natives to do their business away from the temptations incidental to a seaport town, and they, therefore, asked us to take over the whole of the work which they were doing at Thursday Island.

Everything is done on a strictly business basis, because we believe that it is demoralising to give anything for nothing in work of this kind, more particularly in the case of natives, who, like children, soon begin to expect it as a matter of course.

We charge 2½ per cent. commission on all the produce we handle, reasonable retail prices for all the goods we sell, and freight on all the cargo we carry to and from Thursday Island.

All the marine produce is sold in Thursday Island by public tender under the supervision of the Protector of Aboriginals.

Five per cent. of the gross proceeds is handed to the Government, and is banked by them to the credit of the various islands concerned, under the name of Island Fund. This is held as a reserve for the "hungry times," which still periodically occur, and also for any other special need which may arise.

After sundry deductions for gear and food supplies for the boats, and something for the extinction of the debts on the boats, if such exist, the natives receive the balance in cash which is distributed amongst them in proportion to their catch. *Thus each man is rewarded according to the work he has done.*

The Government Auditor regularly audits our books, and all the various arrangements are carried out under the direction and supervision of the local Protector of Aboriginals.

The natives are working with surprising energy under these new conditions. Their villages are steadily improving, they regularly and generously contribute to the support of their churches, and the general improvement in character and physique is most noticeable.

These facts sufficiently prove how keen the natives are to work, when the right inducements are offered, and how capable they are of making good use of their opportunities, if the necessary financial assistance is given to them.

The moral of this and of all I have said is,

1. Believe in the native.

2. Give him a chance to become an independent and self-respecting worker.

3. Let Governments and Christian Missions co-operate in the work of assisting and guiding him on the path of industry.

If we do this our reward will be,

1. An abundant supply of raw material from the tropics for our factories.

2. The opening up of new markets for our goods on an almost limitless scale.

3. We shall have a happy and prosperous people in these distant Possessions who will be a strength to our Empire and a credit to our statesmanship.

But it is even a greater question than this. I have called my paper "The Commercial Future of the Backward Races," but the fate and future of two thirds of humanity involves the fate and future of the whole human race. God has "made of one blood all nations of men to dwell upon the face of the earth." It is His will and our vital interest that we should "dwell together in unity." For good or for ill we are all one body. "The eye cannot say to the hand, I have no need of you, and the head cannot say to the foot, I have no need of you." If the War has taught us one lesson more clearly than another it is the great truth that the whole world is interdependent and the welfare and happiness of every nation is bound up with the welfare and happiness of all the others.

In addition to religion and government, all the sciences, Economics, Sociology, Agriculture, etc., have their part to play in the solution of this great problem, for it involves the destiny of all mankind. Hate, contempt, racial animosities threaten to disintegrate and destroy all the accumulated gains of civilisation, if we are not careful to guard ourselves against them. Idealism has recently been treated with scorn and denounced in high quarters, as a danger but surely the lack of idealism is the greater danger.

If we approach this great and pressing problem of the future of the Backward Races in the spirit of justice, sympathy and love, we shall not fail to arrive at a solution which will benefit us, perhaps even more than those whose good we seek.

DISCUSSION.

MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., who relieved Sir G. Le Hunte in the chair on the latter leaving the meeting to ca ch a train, said Mr. Walker had harped all through his paper upon the need for what he termed the "willing worker." We were not without experience in the older countries of the world as to the distinction between those who worked with a will and those who did not. Lord Askwith, who was present, knew more perhaps than any man in England of the psychology which went to make up the willing worker. Dealing with the problem as it affected the backward races of the world, he thought Mr. Walker had perhaps been just a little unappreciative of what had been done, what was being done, and what it was the definite intention to do in the future in regard to the enlistment of the native willing worker in the development of his own country and for his own advantage. It was true that in certain backward countries there had been matters which he would not call scandals, but rather experiments which had not been always sa i fac or , but what stood out above all in the British administration of certainly the most backward Continent of the world — Africa — was the great success rather than the failure which had attended the enlistment of the willing worker in the service of the world and for himself. Nigeria, the Gold Coast, Uganda and Tanganyika had within the past twenty years been added to the list of, should he call them even, progressive countries, rather than the backward countries of the world. It was the British race which had discovered, or, at any rate, had adopted with enthusiasm, the principle of trusteeship for the backward races. Other European nations which had found themselves called upon by accident or design to take part in the administrative problems of the backward races had not always regarded their responsibility in the same way; but thanks to the great lessons handed down by the missionaries from the days of Livingstone, and thanks to the lead taken in this country a hundred years ago by those who brought about the abolition of slavery, it had never been lacking in our own race to endeavour to give the utmost freedom to everyone who was backward morally or economically, be he black or white. We had lived in this last generation to see that principle of trusteeship for the native races adopted by other European countries, and to see the territories of backward races being administered and developed by way of the willing worker; but the author was right when he said that those matters should be emphasised. They were known and practised, but the more widely known and practised they were the more successful would they be. Mention had been made of the enrolment of a quarter of a million African troops by our ally, France. What he was about to say, of course, was but an individual view, but he could not help thinking, when one realised all the possibilities that might follow from enrolling large masses of the backward races in the military employ of a European power, from furnishing them with arms, and from the teaching of violence which followed, that that was not a forward, but a backward step. If there was to be a new understanding between our country and our ally, France, he trusted sincerely that the Prime Minister and the Cabinet would not overlook the chance of saying a word as to the great responsibility which rested upon the white Powers who administered Africa, and what a fatal thing it was to enrol black men to serve in the armies of white Powers. He regretted that Sir Frederick Lugard was not able to be present; but he had written to the Secretary of the Dominions and Colon'es Sect on as follows: —"I should much have liked to accept your kind invitation to say a few words and to congratulate the lecturer on the success of his excellent scheme of self-help for native races. Dr. Rivers's remarks in his enquiry as to the cause of the decrease in population in Melanesia are very pertinent. He, like Professor Elliott-Smith and others, rightly places the lack of interest in life as the foremost cause of a decreasing native population. Good government is no substitute for this. The recent admirable report from New Guinea, which comes within my work as British Member of the Mandates Commission, gives emphasis to this, I am glad to note."

LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, said, in speaking of New Guinea, Mr. Walker began the history of that country with the Governorship of Sir William MacGregor, and also spoke of the resolutions with regard to firearms and drink as having been first started during the Governorship of that gentleman. That was not quite correct. It was in 1885, before either Sir George Le Hunte or Mr. Walker went to New Guinea, that he (Lord Askwith) was in Papua as an honorary member of the staff of Major-General Sir Peter Scratchley, High Commissioner of the Western Pacific and Governor of a proposed Protectorate of New Guinea, and it was then that those ordinances had been either promulgated or confirmed. He knew that definitely because he had personally assisted in drafting them. He mentioned Sir Peter Scratchley's name because he did not like his old chief to be forgotten. It was unfortunate that Sir Peter died in New Guinea of malarial fever, his body bei g brought back to be buried in another clime. With regard to the paper, he hoped Mr. Walker would not think he was criticising too much when he said that, although he entirely endorsed the idea of sympathy between white and coloured races to which the lecturer alluded, and ac epte l his view that he was not an Extremist, yet he could have wished that some of the phrases in the paper might have been somewhat toned down. He could not but feel that there was a rather unreasonable indictment, in certain of those phrases, of the work which the British Empire had been doing for

many generations past and was at present endeavouring to do. Mr. Walker used the following phrase, for instance—he supposed it alluded to the British Empire—"An Empire that attempts to arrest the progress and development of these many millions of her people, and make of them 'hewers of wood and drawers of water' for all time, is doomed to fall to pieces sooner or later. This is a question of life and death for us as well as for the coloured races, and it will be well if we see this before it is too late. How long will the coloured races of the world submit to such injustice?" and further on Mr. Walker remarks: "There are already mutterings of discontent and stirrings of new life in this dark mass of humanity, which are the early symptoms of coming trouble if *our statesmen* do not learn in time to meet these demands for freedom and opportunity for development which have been too long denied to them." In another place he says "without sympathy and understanding it is impossible for men, white or black, to pull together. If these elements are not cultivated, *war*, with all its waste and misery, *is inevitable*." Then Mr. Walker cited a quotation from a certain doctor's book, in which the strange statement was made:—"What then is the dark world thinking? It is thinking that wild and awful as the Great War was, it is nothing to compare with the fight for freedom which black and brown and yellow men must and will make unless their oppression and humiliation and insult at the hands of the white world cease. The dark world is going to submit to its present treatment just as long as it must and not one moment longer." The lecturer had suggested that violence was not recommended by the doctor himself in that book, but one had a certain feeling of doubt as to where that dire threat was coming from, and whether it was true. Was it from Japan, a nation allied to us in the Great War, whose recent sorrow the Society was going to hear about the following evening from a distinguished member of the Japanese Embassy? Was it from China, where one would think that, if anything, humiliation and insult were being endured by some of the white races rather than the other way? Was it from Siam, a flourishing independent kingdom? Was it from India or the Philippines, where two great nations were endeavouring to find measures of self-government which they could give to the peoples of those countries? Was it from Sarawak, Borneo, Malaya or Burma, countries which we had been accustomed to think we had been successful in governing? Was it from Iraq or Arabia, which we thought we had assisted by overthrowing the dominance of the Turk? Was it from Egypt, to which we had lately given independence? Was it from Uganda or the Sudan or the Gold Coast or any of our colonies on the West Coast? Or, turning to other nations, had there been any signs of revolution in Morocco or in Senegal, or had the black races in the United States of America been proposing to overthrow the Government of that country? He could not help thinking that that statement was a very gross exaggeration. The lecturer had given some very interesting accounts of plantation life in New Guinea. It was important that care should be taken that settlements like Port Moresby should not become centres where half-castes or poor blacks and others should settle round the European Settlement, but that as much independence, assistance and direction as possible should be given to the various valleys and sea coast towns which abounded in that country. When he first visited Port Moresby there was only one house there. Now it was quite a big town. New Guinea, however, would take a very long time to develop. It had deep gorges, razorback hills with high mountains beyond, and its jungles, rivers and swamps were physical features which made commerce on a wide scale very difficult. Further, the white man was not enamoured very much of the insects which abounded there. On the whole, he did not think New Guinea would be of very great commercial importance unless a good deal of gold was discovered there; but the method which was being pursued there was one which seemed to him to be very suitable for the kind of country it was. His criticism upon the paper was that it was very dangerous to generalise in such a wide manner as Mr. Walker had done about the white men and coloured races, and about countries which the lecturer had not himself visited. It was best to look at the problems affecting each of those different countries and to solve them with the will and endeavour to do it, with sympathy and for the advantage and assistance of both races—white or coloured.

Mr. Charles H. Roberts said as he was connected with the Anti-Slavery and Aborigines Protection Society, to which Mr. Walker had given a most handsome testimonial, he might be allowed to thank the lecturer for the way he had spoken about the work of that Society. Mr. Walker had been good enough to say that its work was of value, partly in calling public attention to unfortunate abuses discovered in different parts of the world. Lord Askwith had not put it too highly when he said that the ideals of the British Empire were higher than those of any other previous Empire in its treatment of the backward races, yet he (the speaker) was afraid that we did not always act up to our ideals, and unfortunate incidents had occurred where individuals had not absorbed or acted upon those ideals. Lord Askwith had combated the lecturer's thesis that if the treatment of the backward races was not inspired by the highest ideals of justice, there was a possibility of trouble in future. The kind of trouble which was in Mr. Walker's mind was not that of a forcible attack upon the white position, but that, unless our practice was on a level with our highest ideals, we might find in different parts of the world—Africa, for instance—unrest and racial trouble which would certainly upset equanimity and cause trouble. Even in unexpected places there were to be found signs of revolt against the dominance of the white race. He had read books which had made him feel that that possibility was not

altogether to be ignored. It was quite true that our principle of trusteeship had led to a high level of treatment of the backward races, but he thought that might be qualified by the following consideration: He was not quite certain whether it could be said that in all British-speaking communities there was an absence of colour prejudice. He was not quite sure whether we had not more of a colour prejudice (though we repudiated it in our legislation) than, for instance, the French. It would have been interesting if Mr. Walker had given a few more details of the industrial work to which he had referred. He noticed the rather ominous statement that the particular industrial society referred to had been 17 years in existence, had done admirable work, but had not yet proved a commercial success. Unfortunately, the combination of philanthropy with business was so extraordinarily difficult that, with the very best motives in the world, and with the highest ideals, it seldom succeeded.

COLONEL SIR CHARLES E. YATE, Bt., C.S.I., C.M.G., M.P., said he had been pleased to hear Lord Askwith criticise the manner in which Mr. Walker had failed to appreciate the trusteeship of the British race in connexion with backward races. Although Mr. Walker, he believed, was an Englishman, the bulk of his paper seemed to him personally to be nothing else than a violent attack on his own fellow countrymen. He used the following words: "These are serious statements by one who is fully competent to speak on these matters," but he (the speaker) could not help having a doubt as to whether the lecturer, whose experience apparently was gained in Papua, was competent to speak for the whole Empire.

MR. WALKER pointed out that that was a quotation from Governor Murray.

SIR CHARLES YATE, after expressing regret for the mistake, said he still thought Mr. Walker had looked at the whole matter from a very narrow point of view indeed, and he agreed entirely with Lord Askwith that many of the statements in the paper were gross exaggerations. He felt compelled to disagree with Sir Humphrey Leggett's disapproval of the enlistment of native soldiers. One had only to take India, Egypt and the Sudan to see what splendid men the natives had been made by being enlisted as soldiers; they loved their British officers, and they followed them to death if necessary; and enlistment, he thought, raised them in the scale of humanity, not lowered them. He, therefore, could not agree with Sir Humphrey Leggett in thinking that it was a bad thing for the native to be enlisted as a soldier in the British Army.

MR. TRAVERS BUXTON remarked that in his latest report the Governor of Papua had contrasted the plantation system with the system of native cultivation, very much to the advantage of the latter, if it could be worked. In Papua, which was very backward, it was not possible to get the natives to work as free labourers; indentured labour was necessary. The capitalistic system could not be carried out very extensively, and, therefore, Mr. Murray held that a combination of the two was the right thing for the development of Papua—the capitalistic system, as Mr. Murray called it, and the native working on his own account. Mr. Murray was in this country a few months ago, and had given a most fascinating account of the people of Papua and what he had done amongst them. Those who knew Mr. Murray's reports, and who had followed the work which had been going on in that country, knew what a testimony it was to the sympathetic, wise and consistent administration which had been carried out for so many years by one Governor after another. Reference had been made by Sir Frederick Lugard to the need of supplying the native with an object in life. In some essays on the Melanesian native, published a few years ago, Dr. Rivers pointed out that the native who had been accustomed to head-hunting and tribal wars, when he came to be civilised to some degree, and when the white man came along and insisted on his obeying certain laws and observing order, he found a lack of interest in life—boredom. Therefore, from the lowest point of view, as well as for the reasons on which the lecturer had laid stress, it was very important to get the native to become a willing worker in order to save him from being exterminated, because the result of his intense boredom and lack of interest in life was that he died, and thus became of no use to himself or anyone else.

MR. E. KILBURN SCOTT said he was certain Mr. Walker had had no intention whatever of making any attack on those gentlemen who had so wonderfully administered the outposts of the Empire in the past. The type of men Mr. Walker attacked were the beach-combers and some of the traders.

SIR CHARLES YATE drew Mr. Kilburn Scott's attention to the statement on page 5 of the paper regarding the trouble which it was threatened would ensue in this dark mass of humanity: "If our statesmen do not learn in time to meet these demands for freedom and opportunity for development which have been too long denied to them." He thought it would be agreed that that referred to the men who administered the Empire.

SIR THOMAS J. BENNETT, C.I.E., said that after the discussion which had taken place, he thought the vote of thanks which he was about to propose was less a vote of thanks than a mitigation of censure! Although there was a great deal in the lecture to which he personally objected, the worst parts were not Mr. Walker's; as a matter of fact, the latter were the best. The quotations were the worst parts. He thought the person who had

led Mr. Walker astray had been Mr. Murray. He (Sir Thomas) did object to Mr. Murray saying that the average white man was so masterful and occasionally so utterly devoid of any idea of courtesy that he would ride roughshod over the feelings of the native. Sir Charles Yate had had many years' intercourse with the natives of India, and had not been masterful, devoid of any idea of courtesy, or ridden roughshod over the natives. When that was presented to the world as the sort of attitude of the average white man to the native, personally he rather objected to it, and he would suggest to Mr. Walker that his paper would have been a much more admirable one if he had left Mr. Murray out of it. There was one omission to which he desired to draw attention. Mr. Murray spoke of the idea of the priority of native interests being recognised as a truism to which lip-service was paid, and said that our policy was not really determined by that principle. He was quite sure that that statement had been made before the White Paper on Kenya was issued. Everyone knew that priority of native interests had been affirmed as a principle of high State policy in that White Paper. That was a determining point in the policy of this Empire towards the backward races, and it should be recognised by the audience that afternoon.

Professor H. E. Armstrong, F.R.S., said he seconded the vote of thanks most heartily, for the reason that he thought it had to be recognised that men such as Mr. Walker were a class of individuals who in the past had done this Empire an enormous service, and he was sure the audience were glad to have an opportunity such as the present of thanking one of them.

The motion was carried unanimously.

Mr. Walker, in reply, said he thought he must plead guilty to not having expressed himself sufficiently as to his appreciation of the work of the Administrators of the British Empire. He did recognise that our Empire had the best record of any Empire in the world. He had perhaps dwelt too much on the dark side of the subject. He did not think it was quite true to say that there was not one word of appreciation in the paper of the work which the Empire had done, because he had referred, in connexion with Papua, to the three magnificent men who had been there. He was sorry he had omitted to mention the name of Sir Peter Scratchley, who was a martyr and died in the course of his work. He was a great pioneer Commissioner in New Guinea, and belonged to the very best type of Empire Builders. At such a late hour he would not attempt to deal with the various other points which had been raised in the discussion. He thought the paper was not as worthy as it should have been of such an occasion. He was indeed very conscious of its deficiencies, but he hoped the audience would forgive him. Perhaps he had done Governor Murray an injustice in the quotations he had put in the paper.

The meeting then terminated.

"BAYER 205." A SLEEPING SICKNESS REMEDY.

The Berlin Correspondent of the *Manchester Guardian* contributes an interesting account of an address recently delivered by Dr. Kleine on his experiences and experiments in Rhodesia and the Belgian Congo.

"Bayer 205" is a synthetic drug. Its composition is being kept a secret. It was discovered three years ago. In 1921 the Bayerische Aniline Dye Works asked Dr. Kleine to test its efficacy in tropical Africa, for the tests that had been made in Germany seemed to promise success.

Sleeping sickness is caused by two varieties of flagellate bacilli called trypanosomes and discovered by Sir David Bruce. They are transmitted by two varieties of the tsetse fly, *Glossina morsicans* and *G. palpalis*. Transmission is not merely mechanical. The bacillus has to go through a development that may last several weeks after it has been taken up into the body of the fly before the fly itself becomes infectious.

The disease has three stages. In the first a blood-infection is accompanied by alternating states of feverishness and apparently normal health. In the second stage there is a swelling of the glands. Dr. Kleine showed several photographs of patients whose necks had conspicuous swellings on either side. In the third stage infection of the nervous system, of the spinal fluid, and of the brain-matter sets in. The patients grow violent, and often develop homicidal mania. Eventually they become lethargic and fall into a kind of impenetrable stupor—hence the name sleeping sickness. Dr. Kleine's photographs showed sufferers who were brought to his laboratory on stretchers. Their bodies were terribly emaciated, and their faces had a vacant, stupid look. One photograph showed a homicidal maniac who had been rendered harmless by the Central African equivalent of a strait jacket—a long, heavy tree-trunk with a forked end, into which his neck had been squeezed and fastened.

Dr. Kleine succeeded in curing patients in all the three stages of the disease. In some the deterioration of the nervous system was so far advanced that a restoration to normal health was no longer possible, but the blood of these cases was rendered free of trypanosomes.

Prophylactic Treatment.

This successful sterilisation of the blood is of supreme importance. A patient who has been treated with Bayer 205 ceases to be a source of infection even if he himself does not recover. The complete stamping out of sleeping sickness is therefore only a matter of organisation.

Prophylactic treatment tried on animals was not entirely successful. Experiments were made with cattle, dogs, and monkeys. Dr. Kleine employed a number of negro boys in catching tsetse flies, which were placed with the animals. The number of flies that can carry infection varies with the climate. On an average about one fly in 500 can impart the disease, but as tsetse flies abound in countless myriads, and as each fly can live as much as a year, the danger of infection is very great, indeed whole populations have been decimated by it.

Cattle that had undergone prophylactic treatment did not, after being stung by a parasite-carrying fly, grow emaciated and die, as they would have done without treatment. They showed only slight symptoms of ill-health and remained fit for the market. Monkeys similarly treated developed a slight enlargement of the spleen, but showed no very grave symptoms. There were a few cases of relapse, but these were successfully treated with antimony.

Dr. Kleine's first series of experiments was made at Dombo, a Rhodesian negro village where he and his staff remained for a year. Sick men, women, and animals were brought in, sometimes from a distance of a hundred miles. The patients were not always very tractable. The women particularly wanted to go back to their fields, where they had to stand shrieking and howling to keep the birds away in the mornings and wild animals at nightfall.

The party then crossed into the Belgian Congo at the invitation of the Governor. They were on the march for three weeks. They passed through villages where only women and children were to be seen, all the men being away to catch grubs that are dried over a fire, salted, and kept as food.

At Elizabethville the Belgian authorities gave the part a very friendly welcome. It was here that Dr. Kleine heard that the Ruhr had been invaded. He asked the Governor of the Belgian Congo whether he had not better ret rn to British territory, but the Governor replied that science was science, and that every help would be given to the party of German scientists now as before.

In Rhodesia Dr. Kleine had treated 35 patients. He generally gave three injections, and four or five for particularly grave cases. Subcutaneous injections were found to be rather painful and caused a slight inflammation, so that the comparatively harmless intravenous injections became the rule.

Of the 35, one died from unknown causes. Another, an Englishman, felt so much better that he decided to leave prematurely. He died in London of sleeping sickness. Of the remaining 33 two were dead half a year later (it is not certain from what causes), while the remaining thirty were alive and apparently in good health.

A Malingerer.

Amongst the 150 patients treated by Dr. Kleine in the Congo were 95 children. He kept them under observation for five months, making frequent blood tests. Only in two cases were trypanosomes found in the blood at the end of the five months. It was impossible to tell whether they were cases of relapse or of renewed infection. A boy who was in the third stage of the disease and had become a raving maniac was quiet after three injections. Another was brought in bound hand and foot, but he, too, was cured. A few very advanced cases were not absolutely curable, although their blood was freed from the infection.

The natives were not long in finding out that Dr. Kleine had a special interest in treating them, and they began to demand payment in the shape of tobacco, eggs, or money for being cured. One native, named Ulimengo, was brought to the laboratory in a state of profound stupor. He seemed to be blind, although an examination of his eyes revealed no defect. He was treated with Bayer 205, and blood tests showed that the injections had taken effect, but there was no change in his conduct. A sample of his spinal-fluid was also taken, but no trypanosomes could be discovered. Ulimengo seemed to be quite harmless, and he was made to sweep the approach to the laboratory during the rare intervals when his stupor relaxed a little. For days he would remain helplessly languid, until one morning he uttered the word "pay"—the first word he had spoken since his arrival. Some money was given to him. This treatment effected an instantaneous cure. It was repeated in moderate though regular doses, and Ulimengo, a bright and intelligent lad, was found to be useful in all kinds of tasks.

Many natives suffering from ailments other than sleeping sickness asked for treatment. Dr. Kleine says that they make hardly any distinction between different diseases or between different medicines. Illness is simply illness to them, and any medicine is a cure for all diseases. It was impossible to make them understand that there were specific complaints and specific remedies.

SOURCES OF SUPPLY OF DIVI-DIVI.

Divi-divi is the native and commercial name for the dried seed pods of *Caesalpinia coriaria*, a small tree indigenous to tropical America. This tree grows to a height of 20 to 30 feet, lives approximately 100 years, and bears fruit from its seventh year, though not reaching full development until its twentieth year. A mature tree will, under favourable conditions, yield as high as 300 pounds of pods a season. The pods are 2 to 3 inches long, three-fourths inch broad, one-eighth inch thick, and very smooth. While drying they become curiously curved, frequently assuming an S shape. The tannin in these pods is exceedingly astringent, containing a large proportion of ellagitannin and gallotannin, also a considerable amount of oily and mucilaginous matter.

The tannin content ranges from 40 to 45 per cent. This tannin occurs mainly in the tissues of the pod close to the outer skin, rather than in the seeds, which contain but little. A representative analysis of the pods is: Water, 13.5 per cent; tannin,

41.5 per cent; non-tannins, 18 per cent; ash, 1.6 per cent; and insoluble matter, 25.4 per cent. Every 100 parts of tannin contain 20.2 parts of carbohydrates.

Great care must be taken in the handling of pods for export, for, as the tannin content of the pod occurs immediately under the epidermis, in the form of a white powder, any abrasion of the skin will result in loss of tannin. It is also essential that the pods be packed in fine bags rather than in those of coarse-grained material, which would permit the powder to sift through and become lost in transit.

Divi-divi readily adapts itself to separation into the concentrated extract form. Owing to the presence of a large proportion of carbohydrates and the foreign substance previously referred to, both the extract and the ordinary solutions for tanning purposes are subject to fermentation. Throughout the process of fermentation a deep colouring matter is developed which imparts to leather unsightly dark stains. The problem of effectively avoiding this fermentation has yet to be solved, although the risk can be materially lessened by the use of antiseptics.

The use of divi-divi in the manufacture of leather was known to the Spaniards as far back as 1769, having been first imported into Spain from Caracas in that year. It advanced steadily in European favour during the succeeding 100 years, at the close of which period its use as a tanning agent had become widely extended. It was not, however, until 1915, when tanners found it necessary to utilize all available sources of tannin to meet the war demand for leather, that the use of divi-divi in the United States could be regarded as worth while.

A survey of the sources of supply of divi-divi has been made and published by the Research Division of the United States Department of Commerce, from which the following particulars have been extracted:—

Venezuela has long been regarded as the world's most important source of divi-divi. The general development and economic success of this industry are shown in the export statistics of that product. During the period 1908-1921, Venezuela's exports of divi-divi averaged 6,610 metric tons annually. This average includes yearly exports as high as 10,902 tons in 1911 and as low as 3,956 tons in 1920 and 2,849 tons in 1921; omitting the two low years, the average of the preceding 12 years was 7,145 metric tons. Should a greater demand for this product be created among tanners, Venezuela could increase its output several fold through harvesting of full crop and systematic cultivation. At present only that part of the crop most readily available is assembled in sufficient quantities to fill market requirements.

Before the war, Germany was Venezuela's best market for divi-divi, which is utilized as both tanning agent and dyestuff. Out of a total of 5,371 metric tons exported by Venezuela in 1913, Germany took 5,092 tons. Since 1915, however, the United States has become the principal purchaser.

The high cost of transportation during the war and the desire to eliminate all possibility of waste led to the establishment of two extract factories in Venezuela, located at the ports of Porlamar and La Guaira. At each of these plants the pure tannin is extracted from the pods—by means of a patented process into which neither heat nor the use of any chemical composition enters—and put up in pressed tablets. It is claimed that the tablets, or cakes, ready for export contain an average of 80 per cent. tannic acid and 16 per cent. tannic glucose. No export figures of divi-divi extract are available.

Colombia ranks second to Venezuela as a source of divi-divi. The estimated total annual output is 7,500 tons, the bulk of which is produced in the Goajira Peninsula and exported through the port of Rio Hacha to Curacao for trans-shipment. Decreased demands during the post-war industrial depression produced a general dulness in Colombian trade in divi-divi rather than lessened supplies; but, judging by recent United States imports from Curacao (the greater proportion of which came originally from Rio Hacha), Colombia must be renewing its former activity in this product.

The Dominican Republic's exports of divi-divi formerly exceeded 2,000,000 pounds annually, almost all of which was produced on the arid lands of the Province of Monte Cristi. The output, however, has been seriously affected in recent years by the presence of a species of orchid, which lives as a parasite on the divi-divi tree, frequently killing it, and in every case reducing the yield of pods. Until measures are introduced to eliminate this pest no great increase in exports may be anticipated. The present annual production of the Dominican Republic and Haiti is estimated at 1,500 tons.

The Dutch West Indies have an annual output of about 2,000 tons; all shipments in excess of this amount originate in Venezuela and Colombia.

As a general rule divi-divi pods are leached by the tanner. If passed through a disintegrator the pods are readily broken and the rich tannin powder sifted out, which is mostly soluble in water. A liquid extract containing 25 per cent. tannin is an article of commerce.

Divi-divi is rarely used alone, because the leather thus produced is strongly affected by atmospheric conditions, being soft and spongy in damp weather and lacking pliability in periods of drought. To counteract these tendencies divi-divi is usually mixed with other tanning materials. If used in strong liquors it yields a heavy and firm leather. Ordinarily it is employed as a substitute for gambier in the dressing of leather, and in the rapid drum tannage of light leathers, through means of which an excellent colour may be obtained. Occasionally its use in connexion with leather is merely as a dye.

GENERAL NOTES.

The Physical Society of London: Jubilee Celebrations.—The Physical Society of London, which held its first meeting on March 21st, 1874, is arranging to celebrate its Jubilee from March 20th to 22nd next. The preliminary programme of the proceedings in connexion therewith is given below. Fellows of the Society are invited to be present at the Jubilee meetings. According to present arrangements no tickets will be required for this purpose. Thursday, March 20th, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2: 2.30 p.m.—Opening of Exhibition of Apparatus; 3.0 p.m.—Reception; 3.45 p.m.—Delivery of the Guthrie Lecture by M. le Duc de Broglie on "Photo-electric Effects, in the case of High Frequency, and Allied Phenomena." Friday, March 21st, at the Institution of Electrical Engineers: 4-5.30 p.m. and 6-7.30 p.m.—Reminiscences by Original Fellows and other Fellows of long standing. Saturday, March 22nd, Continuation of Exhibition at the Institution of Electrical Engineers: 7 for 7.30 p.m. Banquet (for Fellows and guests only).

Whaling in Ross Sea.—According to the *Times Trade and Engineering Supplement*, a base for a Norwegian Whaling Syndicate is being established at Hobart, Tasmania, for the conduct of whaling operations in the Ross Sea. Five whalers are already assembled at Hobart, awaiting the arrival of a factory ship from Norway. The expedition carries a licence granted by the British Government, but the operations will be under the surveillance of the New Zealand Government, which now controls the Ross Sea Dependency. The terms of the licence restrict operations to whales and fur seals, and the expedition will not be permitted to interfere with other forms of animal or fish life. A royalty will be collected by the New Zealand Government on all whale oil won. As soon as the factory ship arrives, the fleet will take in stores and proceed to the Ross Sea. The vessels will return to Hobart after a few months' operations, when the ice sets in, and despatch their products to home markets. More extensive operations will follow on the next trip.

Porcelain and Pottery in Japan.—Since the European War the porcelain and pottery industry in Japan, says *Finance and Commerce*, of Shanghai, has been rapidly emerging from the stage of a household industry and has been modernised, so that factories with modern equipment now exist in various centres. In the production of foreign style crockery for export, Aichi-ken, where Seto, the most flourishing centre of this industry in Japan, is situated, ranks first, its total output, domestic and foreign consumption combined, amounting to 32 million yen, or about 50 per cent. of the total for the whole country.

The West Indian Agricultural College.—The West Indian Agricultural College, which is Imperial in scope and interests, was formally opened by His Excellency Sir Samuel H. Wilson, K.C.M.G., K.B.E., C.B., R.E., Governor of Trinidad and Tobago, on October 16, 1922. The College, at present housed in provisional buildings of a substantial character, is situated in spacious grounds at St. Augustine, eight miles to the eastward of Port of Spain. Easy access to it is afforded by the Government Railway and the Eastern Main Road, both of which pass the college grounds. The object of the college is to afford general instruction in tropical agriculture, to give opportunities for thorough training in the science and practice of the subject to those students intending to become tropical planters, investigators or experts in different branches of agricultural science or technology, and at the same time, to provide facilities for the study of tropical agricultural subjects on the part of graduates from other universities and colleges who desire to acquire knowledge of these subjects in tropical surroundings. It cannot be too widely known that the college is open to students and post graduates from every part of the Empire. Copies of the prospectus can be obtained from Mr. A. G. Howell, the West Indian Agricultural College, St. Augustine, Trinidad, B.W.I., or from Mr. Algernon Aspinall, C.M.G., 14, Trinity Square, London, E.C.3.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock:—

March 5.—Major-General Sir Fabian Ware, K.C.V.O., K.B.E., C.M.G., C.B., Vice-Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

March 12.—Alan A. Campbell Swinton, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.) Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., will preside.

March 19.—R. L. Robinson, Member of the Forestry Commission, "The Forests and Timber Supply of North America." Lord Lovat, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O., will preside.

March 26.—Neal Green, "The Fishing Industry and its By-Products." Professor E. W. MacBride, D.Sc., F.R.S., will preside.

April 2.—Sir Lynden Macassey, K.B.E., "London Traffic."

April 9.—Frank Hope-Jones, M.I.E.E., Vice-Chairman, British Horological Insti-

tute, "The Free Pendulum." PROFESSOR C. VERNON BOYS, F.R.S., will preside.

APRIL 30.—BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, 'Roads."

MAY 5 (Monday).—T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MAY 7.—J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation."

MAY 14.—

MAY 21.—PROFESSOR C. VERNON BOYS, F.R.S., "Calorimetry." (Trueman Wood Lecture.)

MAY 28.—MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock :—

MARCH 21.—OTTO ROTHFELD, I.C.S., "Progress of Co-operative Banking in India."

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Monday or Tuesday afternoons at 4.30 o'clock :—

MARCH 4.—THE HON. T. G. COCHRANE, D.S.O., "Empire Oil: The Progress of Sarawak." THE RT. HON. LORD BEARSTED will preside.

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

JUNE 16.—C. V. Corless, M.Sc., LL.D., "The Mineral Resources of Canada: The Pre-Cambrian Area."

CANTOR LECTURES.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

Syllabus.

LECTURE II.—MARCH 3.—The inter-relation of therms in the form of gas and tar and the process conditions which affect their distribution. Further principles underlying high yields of gaseous therms. The chemistry and economics of tar cracking.

LECTURE III.—MARCH 10.—The trend of developments in carbonising processes. The de-ashing of coal and other factors tending to increase the value of the therm in the form of coke.

COBB LECTURES.

Monday evenings, at 8 o'clock :—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MARCH 3 .. Royal Institution, Albemarle Street, W., 5 p.m. Monthly meeting.

Farmers' Club, at the Surveyors' Institution, 12, George Street, S.W., 4 p.m. Dr. A. G. Voelcker, "The Liming of Land."

Transport, Institute of, at the Institution of Electrical Engineers, Victoria Embankment, W.C., 5.30 p.m. Mr. G. H. Thomas, "Air Transport and its Uses."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Graduates' Section). Lieut.-Col. E. Kitsin Clark, "Literature and Engineering."

Chemical Industry, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1. Messrs. R. Whymper and A. Bradley, "The setting of cacao butter with special reference to the development of 'Bloom' on chocolate." 2. Messrs. W. J. Powell and H. Whittaker, "The determination of Pentosans in wood cellulose."

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Mr. J. Jackson, "Development of Methods for the Collection and Disposal of House Refuse."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 7 p.m. (Informal meeting). Mr. R. D. Spur, "The Selection and Location of Converting Plant for supplying D.C. Networks."

University of London, University College, Gower Street, W.C., 5.30 p.m. Sir Harry Stephen, "Criminal Law." (Lecture II.)

5.15 p.m. Mr. A. S. Parkes, "The Mammalian Sex-Ratio." (Lecture VI.)

At King's College, Strand, W.C., 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture V.)

5.30 p.m. Dr. R. S. Seton-Watson, "A Survey of Bohemian History." (Lecture V.)

TUESDAY, MARCH 4 .. Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

United Service Institution, Whitehall, S.W., 3.30 p.m. Anniversary meeting.

Alpine Club, 23, Savile Row, W., 8.30 p.m. Mr. R. W. Lloyd, "Le Col dit Infranchissable."

Metals, Institute of (North-East Coast Section), Armstrong College, Newcastle-on-Tyne, 7.30 p.m. Mr. H. J. Young, "Alloys for Use with Superheated Steam."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Prof. M. von Rohr, "Contributions to the History of the Photographic Objective in England and America, 1800—1875."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. J. Barcroft, "The Respiratory Pigments in Animal Life." (Lecture IV.)

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. J. H. Helweg, "Modern Danish Lyrics, 1870—1920." (Lecture V.)
At King's College, Strand, W.C., 5.30 p.m. Sir Bernard Pares, "Russia before Peter the Great to 1861." (Lecture VII.)

WEDNESDAY, MARCH 5 London County Council, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Sir Napier Shaw, "Modern Meteorology." (Lecture II.)

Oriental Studies, School of, London Institution, Finsbury Circus, E.C., 5 p.m. Rev. W. S. Page, "The Songs of Rabind-Ranath Tagore."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. J. S. Duckers, "Human Nature in Industry."

United Service Institution, Whitehall, S.W., 3 p.m. Col. the Hon. M. A. Wingfield, "The Supply and Training of Officers for the Army."
Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. (Wireless Section). Commander J. A. Slee, "Development of the Bellini-Tosi System of Direction Finding in the British Mercantile Marine."

Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1 (a). Mr. G. D Elsdon, "The Composition and Examination of Beef and Malt Wine;" (b) "The Determination of Coconut Oil in Margarine." 2. Dr. J. C. Drummond and Mr. H. J. Channon, "Effect of Fatty Diet on the Composition of Butter Fat." 3. Mr. G. D. Elsdon, "What is Bondon Cheese?" 4. Mr. T. R. Hodgson, "Cream Cheese" 5. Messrs. R. T. Thompson and J. Sorley, "Some Facts on the Composition and Decomposition of Eggs."

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. I. C. Gröndahl, "Contemporary Norwegian Literature." (Lecture V.)
6 p.m. Prof. K. Pearson, "The Current Work of the Biometric and Eugenics Laboratories." (Lecture IV.)
6 p.m. Miss Julia Bell, "Colour Vision and Colour Blindness."
At King's College, Strand, W.C., 5.30 p.m. Dr. G. F. Hill, "The Artistic Background of Mediæval History —Coins."
At the University, South Kensington, S.W., 5 p.m. Sir Frederick Bridge, "Some Shakespearian Studies." (Lecture IV.)

THURSDAY, MARCH 6 Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Major W. S. Tucker, "Sound Detection."

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Linnean Society, Burlington House, Piccadilly, W., 5 p.m.

Chemical Society, Burlington House, Piccadilly, W., 8 p.m.

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. I. Björkhagen, "Modern Swedish Prose Authors." (Lecture V.)
5.30 p.m. Dr. C. Pellizzi, "Campanella." (In Italian.)
At King's College, Strand, W.C., 5.30 p.m. Rev. F. R. Barry, "The New Testament Perspective."
5.30 p.m. Dr. A. R. Pastor, "Spanish Mysticism." (Lecture II.)
5.30 p.m. Prince D. S. Mirsky, "The History of Russian Literature." (Lecture VII.)
At St. Thomas' Hospital, Albert Embankment, S.E., 5 p.m. Dr. J. A. Murray, "Cancer." (Lecture III.)
At St. Mary's Hospital Medical School, Praed Street, W., 5 p.m. Prof. B. J. Collingwood, "Blood." (Lecture III.)

British Decorators', Institute of, Painters Hall, Little Trinity Lane, E.C., 7.30 p.m. Mr. W. H. Cantrill, "A Pilgrimage to the Hill Towns of Umbria."

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Dr. P. B. Billard, "The New Examiner."

London County Council, the Geffrye Museum, Kingsland Road, E., 7.30 p.m. Mr. C. A. Hindley, "Fabrics used in Upholstery."

Mechanical Engineers', Institution of (Scotch Section), Royal Technical College, Glasgow, 7.30 p.m. Mr. R. W. Wilson, "Repair and Upkeep of Pneumatic Tools" (Midland Section), The University, Birmingham, 7.30 p.m. Dr. F. C. Lea, "Fatigue of Materials."

Royal Institution, Albemarle Street, W., 5.15 p.m. Dr. J. S. Flett, "Modes of Volcanic Action." (Lecture I.)

FRIDAY, MARCH 7 Royal Institution, Albemarle Street, W., 9 p.m. Dr. W. Rosenhain, "The Inner Structure of Alloys."

Philological Society, University College, Gower Street, W.C., 5.30 p.m. Dr. C. T. Onions, "Dictionary Evening."
Geologists' Association, University College, Gower Street, W.C., 7.30 p.m.

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W., 6.30 p.m. Mr. L. Rowland, "Braided Rubber Shock Absorber Cord for Aircraft."

Timber Trade Lectures, Council Chamber, London Chamber of Commerce, Oxford Court, Cannon Street, E.C., 6.30 p.m.

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. H. Lambert, "A Consideration of the Technical and Artistic Qualities of Printing Processes."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Informal Meeting). Commander G. E. C. Damant, "Recovering Gold from the Laurentic."

Metals, Institute of (Local Section), at the University, St. George's Square, Sheffield, 7.30 p.m. Mr. S. Field, "Some Aspects of Alloy Plating."

University of London, University College, Gower Street, W.C., 5.15 p.m. Lord Justice Atkin, "The Origin and Development of Law in relation to Civic Life."
5 p.m. Prof. E. A. Gardner, "The History of Ancient Sculpture."
At King's College, Strand, W.C., 5.30 p.m. Prof. R. W. Seton-Watson, "The Rise of Nationality in the Balkans" (Lecture VII.)
5.30 p.m. (Shakespeare Association). Miss Z. Vengerova, "Hamlet in Russia."
At the Bedford College for Women, 5.15 p.m. Prof. F. Soddy, "How Physical Science has altered the Economics of Life."

SATURDAY, MARCH 8 Royal Institution, Albemarle Street, W., 3 p.m. Prof. Sir E. Rutherford, "Properties of Gases in Vacua." (Lecture I.)

London County Council, at the Horniman Museum, Forest Hill S.E., 3.30 p.m. Dr. H. S. Harrison, "Man's Early Discoveries and Inventions."

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FRIDAY, MARCH 7, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 10th, at 8 p.m. (Cantor Lecture.) EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." (Lecture III.)

WEDNESDAY, MARCH 12th, at 8 p.m. (Ordinary Meeting.) ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.) SIR DUGALD CLERK, K.B.E., D.Sc., F.R.S., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

CANTOR LECTURE.

On MONDAY EVENING, MARCH 3rd, 1924, MR. EDWARD VICTOR EVANS, O.B.E., F.I.C., delivered the second lecture of his course, "A Study of the Destructive Distillation of Coal."

The lectures will be published in the *Journal* during the summer recess.

DOMINIONS AND COLONIES SECTION.

TUESDAY, MARCH 4th, 1924; THE RT. HON. LORD BEARSTED in the Chair. A paper on "Empire Oil: the Progress of Sarawak," was read by THE HON. T. G. COCHRANE, D.S.O.

The paper and discussion will be published in a subsequent number of the *Journal*.

TWELFTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 27th, 1924; SIR ROBERT BLAIR, LL.D., Education Officer, London County Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Bruce, Oswald B., Weston-super-Mare.
Haunz, Charles F., M.Am.Chem.S., Buffalo, New York, U.S.A.
Howgrave, Arthur Atherfold, London.
Porro, Thomas Joseph, Tacoma, Washington, U.S.A.
Shallenberger, Professor Garvin Dennis, Montana, U.S.A.
Vaid, Bakhshi Dina Nath, Rawal Pindi, India.

The following candidates were duly elected Fellows of the Society:—

Franzen, Raymond, Ph.D., Berkeley, California U.S.A.
McCall, William A., Ph.D., New York City, U.S.A.
Mattu, Pandit Jagar Nath, Srinagar, India.
Shaw, Professor Frederick William, B.S., M.D., Rolla, Missouri, U.S.A.

A paper on "The Use of Psychological Tests in the Selection of a Vocation" was read by DR. CHARLES S. MYERS, C.B.E., M.D., F.R.S., Director of the National Institute of Industrial Psychology.

The paper and discussion will be published in a subsequent number of the *Journal*.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1924 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 22nd, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce," and has been awarded as follows in previous years:—

1864, Sir Rowland Hill, K.C.B., F.R.S.
1865, His Imperial Majesty, Napoleon III.
1866, Michael Faraday, D.C.L., F.R.S.
1867, Sir W. Fothergill Cooke and Sir Charles Wheatstone, F.R.S.
1868, Sir Joseph Whitworth, LL.D., F.R.S.
1869, Baron Justus von Liebig.
1870, Vicomte Ferdinand de Lesseps, Hon. G.C.S.I.
1871, Sir Henry Cole, K.C.B.
1872, Sir Henry Bessemer, F.R.S.
1873, Michel Eugène Chevreul, For. Memb. R.S.
1874, Sir C. W. Siemens, D.C.L., F.R.S.

1875, Michel Chevalier.
1876, Sir George B. Airy, K.C.B., F.R.S.
1877, Jean Baptiste Dumas, For. Memb. R.S.
1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S.
1879, Sir William Thomson (afterwards Lord Kelvin), O.M., LL.D., D.C.L., F.R.S.
1880, James Prescott Joule, LL.D., D.C.L., F.R.S.
1881, Professor August Wilhelm Hofmann, M.D., LL.D., F.R.S.
1882, Louis Pasteur.
1883, Sir Joseph Dalton Hooker, K.S.C.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1884, Captain James Buchanan Eads.
1885, Sir Henry Doulton.
1886, Samuel Cunliffe Lister (afterwards Lord Masham).
1887, Her Majesty Queen Victoria.
1888, Professor Hermann Louis Helmholtz.
1889, John Percy, LL.D., F.R.S.
1890, Sir William Henry Perkin, F.R.S.
1891, Sir Frederick Abel, Bt., G.C.V.O., K.C.B., D.C.L., D.Sc., F.R.S.
1892, Thomas Alva Edison.
1893, Sir John Bennet Lawes, Bt., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.
1894, Sir Joseph (afterwards Lord) Lister, F.R.S.
1895, Sir Isaac Lowthian Bell, Bt., F.R.S.
1896, Professor David Edward Hughes, F.R.S.
1897, George James Symons, F.R.S.
1898, Professor Robert Wilhelm Bunsen, M.D., For. Memb. R.S.
1899, Sir William Crookes, O.M., F.R.S.
1900, Henry Wilde, F.R.S.
1901, His Majesty King Edward VII.
1902, Professor Alexander Graham Bell.
1903, Sir Charles Augustus Hartley, K.C.M.G.
1904, Walter Crane.
1905, Lord Rayleigh, O.M., D.C.L., Sc.D., F.R.S.
1906, Sir Joseph Wilson Swan, M.A., D.Sc., F.R.S.
1907, The Earl of Cromer, O.M., G.C.B., G.C.M.G., K.C.S.I., C.I.E.
1908, Sir James Dewar, M.A., D.Sc., LL.D., F.R.S.
1909, Sir Andrew Noble, K.C.B., D.Sc., D.C.L., F.R.S.
1910, Madame Curie.
1911, The Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., F.R.S.
1912, The Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., G.C.V.O., LL.D., D.C.L., F.R.S.
1913, His Majesty King George V.
1914, Chevalier Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.
1915, Sir Joseph John Thomson, O.M., D.Sc., LL.D., F.R.S.
1916, Professor Elias Metchnikoff.
1917, Orville Wright.
1918, Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S.
1919, Sir Oliver Joseph Lodge, D.Sc., LL.D., F.R.S.
1920, Professor Albert Abraham Michelson, For. Memb. R.S.
1921, Professor John Ambrose Fleming, D.Sc., F.R.S.
1922, Sir Dugald Clerk, K.B.E., D.Sc., LL.D., F.R.S.
1923, Major-General Sir David Bruce, K.C.B., D.Sc., LL.D., F.R.C.P., F.R.S., and Colonel Sir Ronald Ross, K.C.B., K.C.M.G., D.Sc., LL.D., M.D., F.R.C.S., F.R.S.

PROCEEDINGS OF THE SOCIETY

TENTH ORDINARY MEETING.

Wednesday, February 13th, 1924.

Sir Aston Webb, K.C.V.O., C.B., P.R.A., in the Chair.

The following paper was read :—

THE TREATMENT OF THE DEATH-WATCH BEETLE IN TIMBER ROOFS.

By H. Maxwell-Lefroy, M.A.,
Professor of Entomology, Imperial College of Science and Technology.

During the last ten years it has been realised that the past, actual or future attacks of the death-watch beetle on all structural timber are of real importance, and if we are to hand on to later generations the fine timber constructions of the past four or five centuries, some definite steps must be taken to deal with this insect.

There has been some public interest in this problem, but it is much more important that there should now be some definite standardised technical knowledge; those who are concerned with the preservation of buildings have no means of knowing how to act.

In this lecture to-night, it is not proposed to attempt to dogmatise in regard to methods which can be adopted; but rather to describe the present state of the problem, in the hope that discussion may arise, and that out of the collected craft of architects, engineers, chemists and entomologists, some methods may be found that will aid those who are concerned in this question.

The position as regards the beetle now comes under three heads :—

(1.) It has attacked buildings, probably from the time they were built, done certain definite damage (observable, of course, only in those that have remained intact) and

ceased. Why the infestation has ceased is a point of great interest: a great many factors are concerned, and I think no one is in a position to say anything definite; but it is clearly a point to keep in mind.

(2.) Roofs, floors, and other constructional timbers are now being destroyed, either from their original state or after reconstruction; there is here a definite infection in progress at the moment, with steady increase of damage up to a point.

I do not propose to mention any buildings which are in this state, but I never enter a building of even partly wooden construction without apprehension that it is now attacked. Fortunately cases of past attack are more common than those of present actual attack; but it is only reasonable to warn those responsible for the care of buildings that examination often discloses actual infestation by living insects; and there is no doubt that a great deal of actual destruction is now in progress. I sympathise with those who will have no examination made for fear of the disclosure of actual attack and consequent cost of treatment, but it is useless to ignore the fact that there is a great deal of damage in progress now.

(3.) The third point is as to infestation of new timbers in roofs, floors, and similar constructional timbers; it is, unfortunately, true that renovations are done with infested wood, and that buildings are becoming infested from this source, which otherwise would remain free. I know of cases at present in which this has occurred; and it does seem a pity to infest a building by bringing into it timber containing the beetle. If greater publicity secured only this, that those who restore did not infest, then great benefit would follow.

In treating of the death-watch beetle to-night, our main interest lies in the insect as such, and in any consequent precautions that can be taken; we may, therefore, first consider the essential facts of the insect's life and habits, so far as these are known.

The death-watch beetle is the larger of the beetles which are found breeding in wood in buildings, furniture, etc.; normally it lives wild in the dying or dead trunks and larger branches of oak, willow, hawthorn, hornbeam, alder beech; it is recorded from maple and sycamore; it has under certain conditions been found in pine in buildings.

In the wild, the beetles emerge on the bark during the evenings of the early summer; the females lay eggs, soft, oval, white, by means of the long ovipositor: it is not certain, but probable, that each egg is laid in a crack or other crevice, away from the light: the beetles themselves do not burrow or destroy the wood; and normally they perish probably by midsummer. The eggs hatch probably within a definite period between two and four weeks; the grub then tunnels inwards, eating the solid wood, usually in the outer sapwood; it feeds the whole summer, rests during the winter, feeds the second summer, and may then become a chrysalis; if so, it becomes a beetle in probably three or four weeks, which rests as an immature beetle and does not emerge till May, two years from the time it was an egg. Under certain conditions, this period of two years may be three, the grub resting over the second winter as a grub, feeding during the next summer and becoming a chrysalis, and then a beetle only at the end of the third summer; one may tabulate the facts like this:—

May-June	1920	Beetles out.	Beetles out.
June	1920	Eggs.	Eggs.
July August	1920 1921	Grubs.	Grubs.
September	1921	Pupæ.	Grubs.
October May	1921 1922	Resting Beetles.	Grubs.
May	1922	Beetles out.	Grubs.
June	1922	—	Pupæ.
July to May	1922 1923	—	Beetles resting.
May	1923	—	Beetles out.

This table may be taken as approximate—Westwood states that the grub feeds for three years and it may feed longer. But the point to remember is that the egg and chrysalis stage are probably definitely short, while the grub and beetle stage may take a much less definite time, 18 to 36 months for the former; eight to 12 or 15 months in the latter.

The only visible stage of the beetle is in its adult form, when it comes out upon the bark at evening; and all three immature stages are spent entirely in the tree.

In the wild, the insect is attacked by another beetle, which hunts it down in its galleries; unfortunately, this is comparatively rare, and has apparently only been found in trees, not in buildings.

An interesting point is that the grub, which does the tunnelling, has within its stomach an organism of a microscopic kind similar to a yeast, which is apparently a necessary factor in the digestion of the wood: this organism exists also in the adults, is probably deposited on the egg when it is laid, so that the grub becomes infected with what is apparently a necessary adjunct to its digestion: similar instances are known in related woodboring grubs; and the point may ultimately prove to be of more than academic interest, as one might well be able to sterilise the egg of its yeast without killing the egg, but still make life in the timber impossible for the grub.

We are concerned with the natural habits of the beetle in its wild state, because it is the basis from which we start to deal with the pest in a building; and the three important modifications of habits which are important in its indoor life are:—

(1) The alteration in emergence;

(2) The date of emergence;

(3) The manner of feeding of the grub.

In large timbers in buildings beetles do not necessarily emerge to the outside, if there are spaces within into which they can get: a colony of beetles may, therefore, continue work deep inside big roofs, and not emerge as beetles at all.

Secondly, under the different temperature conditions of a building, emergence of the beetles or the existence as a beetle may occur at any time of the year; in unwarmed buildings the beetle behaves as it does out of doors, emerging in early summer mainly.

Thirdly, the grubs will tunnel not in the sap wood only, but into solid heartwood, or from one timber into another contiguous one regardless of the relative position of the grain of the two timbers: this last point is an important one in dealing with timber in buildings; and it is probably the cause of the occurrence of the beetle in pine and soft wood.

In putting before you the problem of dealing with this pest, I am trying to concentrate on points which concern its treatment: much has been said and written about how the wood is destroyed, the appearance of wood, the effects from the architectural and engineering point of view, the historical interest of buildings in which the beetle has worked. This is not the place to list the buildings which we definitely know to have suffered or to be now suffering, nor to describe the damage in these buildings admittedly caused by this insect: I think all who have been concerned with the care of old timber roofs know that the damage may be extremely serious, and so much is common knowledge on this point that I need not stress it; but there are three points which need special consideration: How does the roof become infested? Why does the attack stop? How can you recognise an attack deep in an inaccessible structure?

The way in which an attack commences is of great interest, and I offer you three conjectures; they are:—

(1.) That the original timbers are infested when put in place;

(2.) That at any time after construction, the insect is brought in with renewals, repairs, or fresh timber objects, such as floors, pews, etc.; and

(3.) The insect itself comes in.

We have, unfortunately, no knowledge of the third; beetles do fly and may come in to buildings; but it is unlikely and ill accords with what we know of the beetle's habits. All the cases I have seen have pointed to the use of originally infested wood, or the introduction at some time of infested wood for repairs, renewals, church furniture, flooring, or the like. We have one definite case of an oak floor, put in forty years ago, which is now very heavily infested and from which the pest has infested also pews and other furniture: from this case we can judge that other buildings are now in a state that corresponds with an infection between 40 and 80 years ago. In one of the most beautiful buildings in England, the roof was definitely repaired with infested wood within the last thirty years: and I think in most cases one can get evidence of this sort, pointing either to original or to later infection in this way.

The next point is, why an attack ceases: it undoubtedly does cease without reference definitely to anything that has been done to stop it; these cases show an abundance of attack (which one can date for instance, with reference to definite emergences of beetles through a layer of lime wash put on at a known date), abundant further timber to attack, and no evidence of actual attack at the present date. What has happened? Have the beetles come out, flown away and gone elsewhere? Have the grubs perished inside? Has the wood become too dry, or has the yeast perished? We do not know, but we must take account

of the phenomenon. A great sum of money has been spent on buildings in which all attack had ceased: and cases are under observation now where the assumption is that no further attack is proceeding, and the risk is being definitely taken of doing nothing at present to deal with the pest, merely on these grounds.

Lastly, I must deal with one point, the evidence of attack in progress in timbers inaccessible for examination: there are two sources of evidence; one is the holes in the wood from which the beetles have emerged, and which are unmistakeable; the other is the absolutely characteristic oval flattened pellets of excreta, which may pour out of a big roof joist, and which indubitably prove the presence at some time of the beetle. If the holes, for instance, come through a layer, or the timber put on at a known date, then attack was in progress since that date: if absolutely no pellets are found below joists, for instance, over a ceiling that has not been disturbed or cleaned for a definite period, then one has definite evidence that an attack is not in progress.

In each case, one has to judge by this kind of evidence as to what has occurred, or is now occurring: I wish there were time to discuss individual buildings, but it is not our object to-night to focus attention on any but the general principles of treatment.

TREATMENT.

(1.) Prevention of Infection.

The first and most obvious protection is to make sure that nothing is brought into a building that will bring in the insect, whether it be worked or unworked timber to be used for renewal or repair, or wood furniture or flooring. There is, unfortunately, evidence that quite ancient roofs, not hitherto infected, have been infected in this way, and it seems reasonable to make sure that every scrap of timber brought in shall be free: unfortunately, even apparently sound wood may be infested with eggs or young grubs without any obvious evidence, or beetles may be brought in clinging to the timber, particularly if it is to be worked further within the building. The remedy is the obvious one, to treat every surface when brought in so as to destroy any surface infection, to treat every piece of wood, when it is finally shaped and before it goes into position, so that if infected it is freed, and if not, the beetle cannot possibly emerge from that piece of wood. Judging from cases we have had, much infestation has come from renewals or repairs over the last 40 to 80 years, and this is still a source of infection whose effects will show themselves within the next forty to sixty years.

(2.) Surface Treatment.

We then come to treatment of wood *in situ*, where it is possible to get at nearly all or absolutely all surfaces, and where any damage going on can be located, minimised or stopped by a surface treatment. This means that if an attack is going on, the beetles either cannot get out or cannot get in to a fresh surface.

I know of no other treatment but a chemical one: one cannot heat timbers to 130° F. when *in situ*; one cannot, as a rule, use a vapour or any electrical action; and we know so little of the beetle that we have no way of enticing it out.

The ideal surface treatment should have these properties:—

(1.) Penetration, due to wetting power (*i.e.*, to low surface tension in regard to the interfacial action of liquid and wood): this means only that the liquid will wet evenly all cracks, shakes, crevices, etc., not that it will actually penetrate across the grain into the wood itself.

(2.) Killing power on eggs or grubs at the surface.

(3.) A permanent poison to emerging beetles.

(4.) Deterrent to wandering beetles seeking shelter or a place to lay eggs.

(5.) Permanent, not chemically changing or altering in colour in course of time.

(6.) Reasonably non-inflammable.

(7.) Not a virulent poison to man, while in application.

(8.) Not a permanent virulent poison (which could for instance come off choir stalls or lecterns on to moist fingers: corrosive sublimate is a case in point which has been used in this way).

(9.) Not be a varnish solvent for cases where varnished or polished wood is concerned.

(10.) Comparatively simple and cheap.

(11.) Not too smelly.

(12.) Give off a vapour toxic to insects inside the wood.

(13.) Not corrosive to metal used in strengthening or bolting up.

(14.) Applicable as a liquid, as a spray, swab or cream.

(15.) Not form a dust on drying which will eventually in time dust out.

(16.) Not affect the colour of the wood.

We now come to the domain of the chemist; and I fear that the correlation of chemistry and entomology at this point is a new one. In the days when Westminster Hall was being considered, we arrived at this compromise: a mixture mainly of dichlorbenzene, which was a non-inflammable liquid, which had good penetrating power, was a good insect killer, and in which was dissolved about 8 per cent. of soap, paraffin wax, cedar-wood oil. The paraffin wax is a changeless substance, preventing dusting out, holding in the soap, coating the eggs, forming a definite fine film that beetles dislike; the soap is a definite poison, though harmless; the cedar-wood oil was meant as a temporary local deterrent against infection from another part of the building, since the whole building could not be treated at once. I mention this mixture as it has been quoted, but you must remember that as the roof was being rebuilt as a steel roof, it did not really much matter if the beetle were stopped or not, and also that this mixture has not been adhered to, apparently the cedar-oil and the paraffin wax both being subsequently eliminated, if available information is correct.

But much work has been done since then, and particularly in two directions; very stable and permanent soaps, which are more poisonous, have been made with metallic elements, such as barium, zinc, etc., which can also be emulsified with paraffin wax and other ingredients in water as a medium: it is cheaper to use water to the extent, say, of 80 to 85 per cent., if it will carry paraffin wax, a metal soap and a deterrent oil. A typical formula which I suggest is as follows:—

Zinc, or Barium Oleate ..	3
Cedar Wood Oil	3
Soap	1
Paraffin Wax	10
Water	83

This liquid is applied to surfaces with a brush or spraying machine: it leaves a film of the wax, soap and metallic oleate, invisible, not affecting colour or varnish, not dusting out, not a human poison. Where colour is immaterial one might use a copper oleate: one can add a volatile poison, such as dichlorbenzene, or one of those discussed below. In considering this, one must remember that one cannot, as a rule, use creosotes, tar oils, arsenic, or mercury; a common recommendation was corrosive sublimate in spirit, but it is very deadly to human beings, both when applied and thereafter, and it attacks metal.

A mixture used in some buildings has been linseed oil and turpentine; this is an excellent temporary local application, the turpentine driving the insect in, but beetles come freely through it when the turpentine has gone.

Now among the immense range of possible chemicals, there is a very great variety of choice. I give the above as one out of many possible combinations, and any chemist will be easily able to see others. My point is as to whether you can get to anything that really is better than corrosive sublimate, creosote or turpentine.

Of course, there are a variety of circumstances in which the insect occurs, particularly in church furniture, and sometimes no profound chemical knowledge is required, but merely common sense. A case in point is where a few pounds spent on ordinary paraffin, as a simple treatment for infested woodblocks, would have saved an expenditure now to be faced of hundreds; but the cost of treatment with dichlorbenzene, suggested officially on an imperfect understanding of what had been done, was then prohibitive. I have seen cases where actually corrosive sublimate in spirit was the suitable method: and there are also cases where turpentine followed by linseed oil meets a simple problem.

(3.) Internal Treatment.

Cases do arise where one may have to work on a roof *in situ* where all principal timbers are to be left undisturbed, yet where there are believed to be colonies of insects at work deep inside.

My suggestion there is that one can cautiously penetrate into infested wood with a ⅜-inch augur, screw in a pipe, and pump in a liquid which will do three things: it will give off a poisonous vapour, penetrating the burrow systems and killing larvæ; it will leave a permanent poisonous deposit against future attack; it will strengthen badly decayed wood. The difficulty is to choose a liquid embodying these points: as regards the first, it is now known that one can get liquids giving off vapours toxic

to insects among these classes: the petrol paraffin and aliphatic hydrocarbons; the cyclo compounds; the benzenes, xylol hydrocarbons; the acetones and ketones; the hydrogenated phenols and naphthalenes (tetralin, hexalin, etc.); the pyridine, quinoline, and nitrogen group; the nitro-benzenes; the cyanides dissolved in alcohol; the carbon-bisulphide group; the volatile fractions from wood and coal tar distillation; the chlorinated aliphatic compounds, chlorinated benzene compounds or chlor-naphthalene. These are a few of the more obvious whose killing power as liquids or vapours is now established, and among which one can choose on other grounds, and I make this general statement that these classes of substance are generally toxic to insects as vapours or liquids on the results of thousands of tests made, not on this insect, but on other insects, which we have found sufficiently uniform general killing action to warrant the belief that these kill also this grub. In some cases we have detailed tests on this grub itself, which conform generally with other tests; there are probably definite specific substances acting specially on this grub; but we need further experience before we can pick out the one liquid most toxic to the grubs that can also be used in practice.

The second point is to prevent re-infection, and one can use a wide range of poisonous substances inside wood, particularly if colour is immaterial: one would use creosote but for its smell and its lack of permanency; but I think some form of the mineral soap such as copper, barium or zinc oleate is the best. One can use an arsenic compound, but it introduces difficulties. I saw a building injected with cyanide dissolved in spirit: one could use a mercury substance; fluo-silicates and silicon-ester have definite attractions. There is much to be done in this way before one can make a choice.

Thirdly, can one put in a liquid that will strengthen the much decayed timber and still carry a poison and disseminate a vapour? The simplest suggestions are cellulose acetate, synthetic resins, fluo-silicates, hard waxes, silicon ester. I think it is hard to choose, and I have before me twelve different combinations of vapour, poison, filler, which have been tried. In an important case a formula is being used in which acetone dissolves cellulose acetate, zinc oleate and acetone oil; this works well in practice, *i.e.*, in actual application; and it has also been varied by the introduction of tetralin in place of acetone oil, the tetralin not having the objectionable acrid odour of the acetone oil. It is pumped in at spots judiciously chosen where there is reason to think grubs are at work; or badly decayed wood is saturated with it, to ensure complete sterilisation and to add strength. Impregnation of a system of burrows is not difficult; impregnation of solid timbers requires great time and considerable pressure; it may take hours or days to work the liquid along timber into a burrow system where the grubs are, but it can be done with comparatively simple apparatus, and its application as a method is mainly one requiring a little experience and judgment.

(4.) VENTILATION.

A last point of general treatment is one that is impossible to prove experimentally without abundant time, but frequent observation impresses it on one; it is the enormous influence of ventilation: wood that is kept well ventilated, even if attacked, will not ultimately perish. In two prominent buildings in London, of about the same date, one was attacked at the base of the principal rafters only, where they ran into the walls; the other had been attacked, but the attack had ceased, the whole timber structure being remarkably ventilated. I think that this point is continually coming up, and observation does correlate ventilation and immunity in a decisive way. Perhaps insufficient attention has been paid to this point, and perhaps there may have been cases where it would have been a sound policy to improve ventilation, to watch at intervals for evidence of attack, and to exercise patience before actually dealing structurally with a roof or floor; when an insect reproduces only at two or three year intervals, it takes a long time for an attack to develop, and one can afford, perhaps, to wait awhile and see whether improved ventilation alone will not prevent serious extension of damage.

It is not the intention of this paper to lay down methods, but rather to focus attention upon certain points, and I would like to emphasise the present position.

We are very ignorant of the beetle's life history and habits, mainly from lack of time and opportunity. My first investigator was available for only a few months; I have given such leisure time as I can in

the intervals of a fairly crowded life. We have had little live material, and it would help if some one could get abundant material and give his whole time to the problem.

We badly want to get correlated the experience of those, in all parts of the country, who undertake to deal with cases of this sort; there are many such, but I know of no collected record of their experiences.

Thirdly, we do want to record for posterity what is done, so that our successors may find in the records of each institution a clear statement embodying the conditions as found, and the nature of the work done, so that they may judge by the results.

Lastly, I do think this is a serious matter that should be properly dealt with by some competent public body, so as to secure continuity and uniformity; it is novel, experimental, and not as yet on an established basis of experienced practice; we shall not see the results of the treatments experimentally done; and if the many fine timber buildings are to remain it will only be if this menace is dealt with.

I would here acknowledge the assistance I have had from Sir J. J. Dobbie and Mr. Noel Heaton on the chemical side: it was the late Sir J. Wolfe-Barry's munificence that made possible the original enquiry commenced at Westminster Hall. I have not consciously quoted from published papers, but you will find references to them in the Review of Applied Entomology.

To H.M. Office of Works I am indebted for access for some years to Westminster Hall, and also for a tree cut down for me in Richmond Park last year; and I owe thanks to those in charge of many buildings and churches for opportunities of investigation.

DISCUSSION.

Mr. William Woodward, F.R.I.B.A., was sure everyone present had been delighted to have listened to the paper, which was obviously the result of very great research. The subject was of the highest importance from the point of view of everybody connected with the preservation of buildings. He desired to mention the roofs of three buildings which had been infested with the insect, and the methods of restoration which had been adopted by the respective authorities. First dealing with the roof of Westminster Hall, everyone would be agreed that there was no finer example of carpentry work, both in regard to its design and execution; but what had been done when it was found that some of the timbers were infested with the death watch beetle? Instead of the contractor employing skilful carpenters to take out the defective timbers and to put in their places sound timbers of the same character, the officials had proceeded to insert steel girders. Why they had done so was a complete mystery to him. In the first place it was thoroughly inartistic and unarchitectural, and in the second place, steel was subject to expansion and contraction and to oxidation, which might affect the remaining timber. He did not hesitate to say that the result would be an enormous waste of public money. The work could have been done in a much more simple and inexpensive manner, and in a way which would have been more conducive to art and architecture.

His second example was that of the roof of Limehouse Church. Some time ago attention had been called to the fact that the roof of this church was being attacked by an insect. He had been shown a specimen of the insect. That roof was now being restored, and he had sent a contribution towards the cost of the work on the condition that no steel or iron was employed in that restoration.

The third roof he desired to mention was that of Middle Temple Hall. In the *Morning Post* on the 28th December there had been a very interesting article on that roof, to the effect that "Sir Aston Webb, President of the Royal Academy, Prof. Lefroy, the entomologist, and Mr. Basil Mott, the engineer, have in consultation advised a scheme of repairs which is now being carried out. It involves strengthening the highest collars with plates, and restoring some of the age-worn minor timbers, and also dressing the whole with a special gaseous preparation made by Prof. Lefroy." The word which had disturbed him on reading the article was the word "plates." He had wondered why Sir Aston Webb had ever consented to the putting in of plates. It did not say whether the plates were of iron or steel, but he assumed that they were of metal, and he had been surprised that such a great architect as Sir Aston Web had consented to the introduction of plates in the restoration of a series of collars in the roof of Middle Temple Hall.

As an architect, he considered it was a most important thing to find a remedy which would stop the ravages of these particular insects. It might be that that remedy would be found in some of the liquids of which the author had given a list in his paper. Personally he was one of those who believed that the proof of the pudding was in the eating, and he would ask the author if he would kindly take him to Westminster Hall 400 years hence in order to see the effect of one of the numerous liquids which it was proposed should be put on the roof.

Sir Frank Baines, C.V.O., C.B.E. (Director of Works, H.M. Office of Works), said it had been a great privilege to him to listen to the paper that night, because H.M. Office of Works had had valuable assistance from the author in the past with regard to the problems which they had had to face. The most important point which

the author had brought out—a point which would particularly appeal to architects—was that the attack of the beetle appeared to be so universal and so prevalent that there was probably hardly a mediæval structure in this country which was not, or had not been, infected by it at some time or another. If the author had only brought out that one point he had done a great public service, because the priceless mediæval timber structures which existed to-day required expert examination and opinion as to whether they were infected by this odious little creature. One very important fact which had been brought out by the author had been confirmed by Dr. Paine, namely, the existence of that curious yeast in the stomach of the larva of the *xestobium tessellatum*. He would like to ask the author whether it would be possible for him to suggest an investigation into the question of whether the attack on the grub should proceed on the lines of destroying that yeast.

Another thing he would like to ask the author was his opinion of the real toxic effect of the first solution which had been used by H.M. Office of Works under his help and advice, namely, tetrachlorethane with trichlorethylene as a diluent. That had been used originally at Westminster Hall, but it was afterwards found to be such a virulent poison that its use had had to be dispensed with. The Office's opinion had been that the author's advice in that matter had given them probably a very good insecticide, and they had been very sorry that the solution had had to be dropped. He would like to ask the author whether he thought its toxic influence on the workmen could be overcome, and would it be possible still to use a solution of that kind? It had been said facetiously that its mere name alone would make it a sufficient insecticide, but that might also apply to many of the other solutions which the author had described.

As to the question of using paraffin oil, he must say that he should be very hesitant about lifting a wood block floor in an important building and impregnating the blocks with paraffin oil. He should feel that that would introduce a fire risk which was dangerous and which ought not to be incurred. Further he should feel that the permanence of the treatment was very much in question, because paraffin oil volatilised within a comparatively short time. He would like to know the author's opinion as to the permanence of the effect of paraffin oil in such a case.

The theory of the use of dichlorbenzene, which H.M. Office of Works had been employing in agreement with the author of the paper, was to destroy the waxy-like covering of the larva first, and then to penetrate into each living cell of the insect and to act as a kind of dehydrating agent which would destroy the metabolic action essential to life. If that was so, he would like to know from the author whether that was a genuine description of its probable toxic effect.

With regard to the very interesting formulæ which the author had put upon the screen, although personally he had no chemical knowledge whatever, he did feel as a practical architect that he would rather hesitate to use a solution which had as much as 83 per cent. of water in it, because his experience showed him that to introduce water into an old timber structure would first of all probably set up dry rot, secondly would cause warping, and thirdly would hasten incipient decay. With regard to dry rot, in certain of the structures which he had seen he found that dry rot was almost as serious a problem as the attack of the death watch beetle, and dry rot was prevalent to such an extent that he should certainly, except under the most expert advice, refrain from using a solution with so high a percentage of water.

With regard to the many suggestions which had been thrown out as to toxic preparations which could be used to eradicate the death watch beetle, that was really the problem. Could the author state whether cellulose acetate, for example, was really going to be permanent in action? Was it really a toxic treatment against xestobium? Was it a treatment which would be only effective on the surface of the timber, or was it a treatment which had to be extended throughout the whole body of the timber by a system of boring and penetration? If a preparation, selected by specialists like the author, had to be applied throughout the whole body of the timber of the roof, it was a very big matter indeed. In the case of Westminster Hall it would have involved the penetration of 50,000 ft. cube of oak timber, and that was a problem which, as a practical man, he could hardly face.

With regard to the question of the termination of the attack of the xestobium, he could say from a wide experience that there was hardly a single mediæval structure with which he had been concerned which did not show some signs of an attack. He had thought at certain times that that attack had actually terminated before he had finished with the structure, but he had found definite evidence of the existence of live larvæ in the roof. He had even found in timbers in Westminster Hall, where the attack had been considered to be entirely over, that when those timbers had been removed and split, there were evidences of live larvæ in them. He would like to ask the author whether there was any direct evidence that structures which had been attacked by xestobium showed definitely that that attack was over and finally finished. If there was such evidence which could be trusted, then it appeared to him it would be a guide as to how conditions could be produced which would terminate the attack.

He thought the author's point about ventilation was a most important one. Indeed it had been on the author's advice that he had provided a much increased ventilation in the roofs of certain of the structures dealt with by H.M. Office of Works. He thought the point of ventilation could not be too strongly emphasised.

In conclusion, the whole matter was one which called for very close and continuous enquiry. It would be very helpful if the author could state in a brief form how the investigation had advanced

and what was the position at the present day, and if he would lay down in scientific language the points of failure. The failures were not too grave to overcome. Personally he had visualised the possibility of dealing with structures in the future by again treating them with some perfect insecticide against *xestobium tessellatum*, such as he hoped the author could invent.

MR. NOEL HEATON said the author had been very generous in referring to his assistance in the paper, but he felt that the obligation was entirely the other way round. For many years past he had done a good deal of work in connection with research on building materials and he had at various times been approached to give advice on the matter dealt with by the author, but had always felt chary of expressing any opinion as to the best method of treatment for destroying this pest, because it was more an entomological than a chemical problem.

Recently, however, he had had the opportunity of discussing this matter on several occasions with Professor Lefroy, who had given him an immense amount of information. As a result of their discussions he had formulated some hypotheses as to the materials and processes to be used for exterminating the pest, and he thought that it was only by co-operation of this kind that such problems could be solved. In many respects the difficulty of the problem was on parallel lines to that of the preservation of stone. One of the great difficulties, for example, was to find a means of getting adequate penetration of the poisonous material applied to the wood in order to rout out the beetle or to kill it *in situ*. Linked up with that problem of penetration were all sorts of other difficulties which had been clearly stated by the author and which showed how extremely difficult it was to find a really efficient method of attack. One point had often occurred to him, namely, whether fumigation of the wood would be a preventative of the attack of the beetle. In mediæval days most timber roofs were subject to constant fumigation, owing to the burning of incense, and he had often wondered how far that would act as a preventative. He would like to ask the author his opinion on that point, and whether anything definite was known as to whether the ravages of the beetle dated back to mediæval times or were comparatively recent.

Before one could determine the method of attack, one wanted considerable information on the question of the toxicity of different substances to insects. It seemed to him that in the past a great mistake had been made in trying to get rid of the beetle by the use of substances which were strongly poisonous to human beings. There were poisons which were harmless to human beings but which were fatal to insects, and he thought that was a line of research which was clearly indicated. On the other hand, there were poisons which were harmless to insects but which were fatal to human beings, and in that connection he might mention that during the war he had found that chlorine gas had no effect on flies or butterflies.

He would like to ask the author whether the use of walnut oil had been tried. It was well-known that everything connected with the walnut tree seemed to be extraordinarily antipathetic to insects. He therefore imagined that walnut oil might have toxic properties to insects, and therefore might possibly be a better substance to use than cedar wood oil.

One important point in the preservation of modern buildings was the treatment of any new wood which was put in in the course of re-construction, in order to make quite certain that one did not re-introduce beetles in the place of those which had already gone out.

The question of the cessation of the attack seemed to be a very puzzling one, and he would like the author to give a little more information as to whether there was any evidence as to when the attack ceased. He would like to know, for instance, whether cases had been found where the beetle had disappeared before the destruction of the timber was complete, and there was still, so to speak, plenty of food in the larder; or whether it was simply that the beetles moved to a fresh area after having completed their work of destruction. If there were cases where the attack had begun and ceased before any serious damage had been done, clearly something must have happened to frighten the beetle away. Was there any evidence as to what that something must have been, apart from the question of increased ventilation?

MR. A. R. POWYS said there was very considerable danger in the repairing of timber buildings not suffering from the ravages of the beetle, in the use of old timbers. There was to-day a great vogue for antiques. Men who were living in ordinary modern houses often desired to make them appear old, and in order to do this bought up pieces of old buildings and fitted them into their new building. That was one way of introducing the beetle into buildings which had been up to that moment free from an attack.

MR. W. A. FORSYTH F.R.I.B.A., said he had only studied the question more or less superficially, but he had found that in roofs which were unventilated the beetle was most prolific and active. In one roof with which he had had to deal, which had been in position since the end of the 13th century, and which had nothing but ventilation and light in it, the timbers had survived to this day without any sign of any insect whatever. He would like to ask the author why he had not referred to light as one of the conditions which were unfavourable to the insect. As far as he had observed the ravages of the beetle were of recent origin, and he desired to ask if any investigation had been made as to the length of time during which the

insect had been known to exist. His own view was that most of the ravages occurred in roofs. The heat of a building rose into the roof, and his own belief was that the beetle flourished to a greater extent in heat, and where there was little light or air than under any other conditions. There was one type of oak structure which did not seem to suffer intensely from the action of the death watch beetle and that was a belfry. An oak belfry seemed to stand a visitation of the insect remarkably well. That was mainly because it was subject to intense ventilation and very strong light. He sincerely hoped that the author could continue his investigations into the matter.

Mr. R. à-Ababrelton said in South Africa one could occasionally take door posts and things of that sort in one's hand and easily crush them. That arose simply from the attacks of ants. He had been wondering whether ants attacked wood also in this country. Sir Frank Baines had asked if the use of paraffin was effective. In 1906 he found on his return from South Africa two old chairs in his house which had been attacked by the beetle. He heavily dosed those chairs with paraffin. He went back again to South Africa and, after his return in 1912, had found that the insect had not been entirely eradicated from the chairs. He thereupon gave them another great dose of paraffin, and apparently the insect ceased its ravages until a few days ago, when seeing the notice of the lecture, he had thought it well to look at those chairs again. He then found indications that the paraffin had *not* been entirely effectual.

Dr. W. Rushton Parker enquired if X-rays would be of any use in diagnosing whether or not the beetle was in timber.

The Chairman (Sir Aston Webb) said he was much interested, and to some extent puzzled, in the problem under discussion. It had been asked over and over again, why did the attack suddenly cease? That was one of the things which everybody interested in the matter desired to know. He supposed it ceased because the beetle went elsewhere. The beetle itself did not do the harm, except through the fact that it laid its eggs somewhere, and he supposed that when the beetle was satisfied that there was not much more to be had in a particular building it departed and laid its eggs elsewhere. He had received an enormous amount of help from the author, and any little knowledge he had obtained about the subject he had got from Professor Lefroy, and he was very grateful to him for it.

Ventilation was, no doubt, a very important point. He had found, as others had, that places which were heated were those most attacked by the beetle. It seemed pretty clear, therefore, that ventilation was a very desirable thing to provide. Another thing he had found was that the insects seemed to attack the main timbers more than the smaller timbers. The author had showed some very interesting sections, one of which appeared to show the grubs going at right angles to the grain of the wood. He imagined that that was very unusual, as generally the grubs appeared to run with the grain of the wood. Quite recently he had had occasion to have X-rays taken of certain timber which had been affected, and in all those cases the grub was seen travelling with the grain of the wood, avoiding the hard portions which divided the various grains. Evidently, however, from the author's section the grubs did occasionally go the other way about.

He had found some difficulty in saturating timber with liquid. One could bore holes in the wood and force the liquid into the hole, but it did not follow that one could get it to go exactly where one wanted it to. He had found it very useful to bore through the wood until one came to a shake in the timber. The liquid would then follow the shake, and so one would get over a great deal of the timber which was most likely to be affected. The same applied to the joints. Liquid could be forced into the joints and into any shakes anywhere. If one took a timber and marked on it where it was most affected one would always find little marks round the joints, because the beetle got into those fine cracks, and laid its eggs in the crack, and then the grub came out. The same was the case with the shakes. The beetle got into any little opening of that form, and started on the softer wood in the shakes.

With regard to the treatment of roofs, each one of those concerned had to take the responsibility of doing what seemed to him the best in the way of stopping the decay, in whatever manner he thought best under the best advice he could get. Personally he should like to say that he thought Westminster Hall roof a very fine design. He hoped Mr. Woodward might live for 400 years and see it still there. It was the duty of architects and others to take every possible step they could to ensure, with the knowledge which they had (which even the author admitted was at present defective), the preservation of buildings for the next generation, and for as long as they possibly could, taking advantage of all the advice and expert information which they might have at their disposal.

The Author, in reply, said he did not think there was anything practical to be gained in dealing with the yeast. The point had been investigated, and if it was possible to deal with the yeast as a means of dealing with the insects it would be found out. At the present moment he was afraid it was more interesting than practical. Certainly the best poison had not yet been discovered. Dichlorbenzene was by no means the best; he thought chemical knowledge could give something better. Sir Frank Baines had asked how long the paraffin oil put on floor blocks would last. In the particular case which he had in mind the paraffin oil lasted sufficiently long for the purpose. Sir Frank Baines also objected to 83 per cent. of water in one formula which he had given, but

he would like to point out that that was a surface treatment. The water was not pushed into the timber. Water treatment was possible where it was a purely surface treatment, and he only suggested it in that connection.

One point had been raised about the cycle. Could the cycle be broken; that was to say, could the insect be interfered with in its three years' course so that one generation was stopped? He thought it was a mistaken idea. Although the insects did take three years to develop, they did not all, so to speak, start in 1920. There were some which started in 1920, some in 1921, and some in 1922, so that although the whole cycle was a three-year one, by simply breaking it at one point one was not going to stop it at all. He had heard that point of the cycle discussed before, but he thought it was a very doubtful point indeed.

With regard to the cessation of an attack, everybody was very much in the dark about that. As to whether ventilation and light affected the cessation of an attack, he had seen cases where he was absolutely certain that an attack had started; there had been abundant wood, and everything had been right so far as one could see, and yet the attack had ceased. He had no knowledge as to why. It was one of the most interesting problems in connection with the matter at the present moment as to why an attack suddenly stopped. If only the factors about that could be discovered the problem could be tackled in a much better way. With regard to Mr. Noel Heaton's point about the fumigation of incense, so very little was known about the subject that he did not think anyone knew of a case of a building in which incense had been regularly used which had been affected with the ravages of the beetle. He imagined Sir Frank Baines and others might know of cases where incense was being still used, and where the building was or was not being attacked. He imagined, speaking as an entomologist, that the continued use of incense in a building would prevent attack by the beetle, but it was a point on which there was no information.

One very interesting question had been raised, namely, when did the attacks start? Were they all of the last two centuries, or did they start with the buildings themselves? He was sorry there was so little information on the subject. It was quite possible that no building had been attacked until within the last two centuries. He wished that more was known about it. It all went to show the importance of getting information and correlating it.

Ants did not occur in timber in this country. He did not think X-rays could be used to find out whether an attack was going on.

With regard to the penetration of timber with a liquid, it would be within the knowledge of Sir Frank Baines that experiments were made before Westminster Hall treatment was started with penetration of timber, and it had been shown that if the liquid was pumped into solid oak for, say, six months, it would penetrate a beam 20 ft. long right through. He did not think it was a practicable thing to soak timber with a liquid in that way.

The meeting then terminated.

OBITUARY.

Henry Somerson Freeman.—Mr. Henry S. Freeman, who died on February 22nd, at his residence at Nutfield, Surrey, at the age of 81, was elected a Member of the Royal Society of Arts in 1881. He served for five years in the Bombay Gas Company, and in 1869 was appointed engineer to the then Wandsworth Gas Company. He continued to act as engineer and consulting engineer to this company for twenty-eight years, and subsequently as a director for nearly twenty-five years. On the amalgamation of the companies in 1913 he became one of the directors of the Wandsworth, Wimbledon and Epsom District Gas Company. He was largely responsible for the policy whereby the company has built up its fine modern works, with half-a-mile frontage on the Thames, and a fleet of sea-going steamers.

Mr. Freeman was a keen sportsman and athlete. On one occasion he came in second in an all-England swimming race from Putney to Hammersmith; he won numerous cups for sculling and rowing; and he was a keen cricketer and a good rider to hounds.

MURRAY RIVER WORKS.

Some interesting particulars of the irrigation works on the Murray River were recently given by a Melbourne correspondent of the *Times Trade and Engineering Supplement.*

There will have to be great development along the River Murray, with a corresponding increase in production for which a profitable market can be found, to justify the expenditure of £10,000,000, which is the latest estimate of the cost of the conservation and irrigation works now in course of construction.

The River Murray, Australia's greatest watercourse, is bounded on each side by rich tracts of country which can be converted into productive areas by irrigation. This is being done, but the most serious problem confronting the enterprise at present is the discovery of markets to absorb the ever-increasing volume of production.

The principal work now engaging the attention of two of the constructing authorities—New South Wales and Victoria—is the Hume reservoir, the main storage basin situated half a mile below the point where the Mitta Mitta River meets the Murray. In this dam 1,100,000 acre feet of water will be impounded by an embankment 3,600ft. long. It will have a full supply level of about 73ft. in depth over the flats on the Victorian side, increased to 94ft. in the river channel. This storage will rank amongst the greatest in the world. It will be the fourth largest reservoir, those

exceeding it in capacity being the Elephant Butte dam, the Assuan dam, and the Roosevelt dam.

The embankment 32ft. wide on the top with crest at 12ft. above full supply level, will extend across the alluvial flats on the Victorian side, where the granite occurs at a depth of about 34ft. below the surface. The slopes are 3 to 1 up-stream and 2½ to 1 down-stream. The embankment is being constructed with a concrete core wall carried down to the granite, the material on each side of the core wall being specially selected and consolidated. The spillway is being constructed to avoid undue submergence of adjacent lands by high floods coming down on top of a full reservoir. It will be capable of discharging 100,000 cu. ft a second, and will comprise a concrete dam 710ft. long, having movable gates. Piers carrying the roadway will rise above the concrete and will act as supports for 31 gates, each 20ft. wide and 15ft. high above the crest. In flood times these will be lowered behind the up-stream face by suitable gearing operated by turbines situated in a chamber within the dam. It is estimated by the constructing engineers that a surcharge of 15ft. over the concrete wall will be sufficient to discharge the maximum flood. For ordinary regulated flow discharge eight outlet pipes 6ft. in diameter, with suitable controlling valves, are being provided on the New South Wales bank.

A new lock and weir, No. 9, is being constructed in South Australia to divert water from the Murray into the Lake Victoria storage. This natural reservoir is designed to safeguard South Australian interests. It will be fed during the flood period through Frenchmen's and Rufus Creeks, and when completed will form a balance storage of great value for supplying the lower Murray during periods of low flow. The needle weir regulator which has served for a number of years to hold back a part of the flood waters will be superseded by a permanent structure, which will include extensive embankments with regulators to maintain the height of the water in the lake at within 2ft. of the height of the pool in the lock and weir immediately above. The lake storage will then be about 6½ miles long, with a water surface of approximately 30,000 acres, a maximum depth of 34ft., and a storage of 514,000 acre feet.

When these two large storage basins are completed the depth of the river will be maintained by a series of 35 weirs and locks, so that the full length of the stream may be open for navigation all the year round. This will mean a cheapening of transport and a consequent reduction in the cost of conveying products of the Murray settlements to the sea-board for shipment oversea. Irrigation, however, is the paramount consideration, and the work is being proceeded with towards this end.

RED OXIDE OF IRON INDUSTRY OF MALAGA.

Among the more important products exported from Malaga is red oxide of iron. It is mined to some extent in the Province of Malaga, but principally in the mountainous regions in the Province of Jaen. The crude ore is carried from the mines to Malaga, where it is levigated. In a few instances, reports the United States Vice-Consul at Malaga, it is still necessary to carry this ore some little distance on mule back to the nearest railway, but nearly all of the larger mining companies now possess overhead cables which connect the mines with the main line.

The ore milled in Malaga is reputed to be of very good quality, not equal in colour to the more expensive variety mined in the Persian Gulf region, but much higher in ferric-oxide contents and therefore of more value as a preservative for iron and woodwork. Moreover, the Persian ore is only shipped in the crude form, there being no levigating or grinding plants on the island of Ormuz or in Persia.

A small amount of crude red oxide of iron is exported from Malaga, but the demand is becoming greater every day for the levigated ore, owing to the cheapness of production in that district.

The levigating establishments, which are located in Malaga, reduce the crude ore to a fine pulverised form after having extracted all impurities. The systems of levigation vary, but the most satisfactory appears to be "water floating," which is accomplished by passing the mineral through a series of tanks so that only the very finest particles in suspension ever reach the final or "settling" tank.

The red-oxide industry has expandod considerably during the last 10 years, as is evidenced by the following figures of levigated ore exported to the United States alone:

Year.	Quantity.	Value.
	Pounds.	*Dollars.*
1913............	1,336,968	113,938
1920............	7,459,583	178,314
1921............	7,669,665	176,886
1922............	9,196,123	192,177
1923 (first 6 mths)	6,705,542	133,775

The greatest increase has occurred during the past three years. This is accounted for by the growing use of paints in construction work of all kinds. The present boom in construction, which is most notable in England and the United States, has substantially aided the red-oxide trade. The cement and rubber trades also now consume large quantities, and a large amount is used in paper staining.

Approximately 60 per cent. of the ore exported from Malaga is shipped to the United States, about 30 per cent. goes to the United Kingdom, and the remaining 10 per cent. is taken by various other countries.

THE BRISTLE INDUSTRY OF TIENTSIN.

Bristles constitute one of the leading items of export from Tientsin. According to the Chinese maritime customs returns, exportation of bristles from Tientsin in 1919 amounted to 2,287,723 pounds; in 1920 to 2,506,933 pounds; and in 1921 to 1,890,400 pounds. The returns show that the bulk of the bristles go to the United States. England, France, and Japan, however, share a portion of the trade. The annual declared-export returns for the same periods show that shipments of bristles to the United States amounted to 1,258,784 pounds, valued at $1,857,015, in 1919; 1,649,828 pounds, with a value of $3,547,599, in 1920; and 1,107,003 pounds, worth $1,535,786, in 1921.

Hotou (located at the terminus of the East Grand Canal) is a large distributing centre in North China. Here bristles are brought from Tsunhua, Yungping, regions outside the great wall, and Manchuria, and, after being sorted and graded, are sent to Tientsin by junk or railway. Paotingfu and Peking are other large bristle centres, whence shipment is made to Tientsin either by railway or, from Paotingfu, by river. It is believed that the Paotingfu article is slightly inferior in quality to the Hotou product. According to a report by the United States Consul-General at Tientsin, there are several ways for working the bristle business for export from Tientsin. The principal amount is exported in assortments of 55 or 66 cases, but other assortments containing 8, 40, 100, etc., are sometimes made to meet special demand. Of the usual assortments, the 55 is considered the most desirable because it contains a greater amount of long-length bristles. One of the usual type of 55-case assortments contains about the same number of cases of bristles of each length, from 2½ to 5½ inches. The bristles are packed in cases of 110 pounds net. The 66-case assortment generally sells for about half as much as the 55, which is due to the fact that it contains a very large number of cases of short lengths. Other factors that govern the price are the cleanliness of the bristle, the colour, the elasticity, and the degree of solidarity of the bundles.

THE MONGOL LEATHER BOOT INDUSTRY.

One of the most important industries in Kalgan, writes the United States Consul of that place, is the manufacture of Mongol boots. The dress of the Mongolian people is quite different from that of the Chinese people, and probably the most distinctive feature of the Mongol's dress is the curious, toe-tilted, decorated leather boot. The same style of boot is worn winter and summer by Mongol women, men, and children. It has no raised heel, but is whole-soled from tilted toe-tip to the heel. The upper is made of locally tanned leather, in tan or black, and extends to a height of 15 inches in the back, and about 16½ in the front. The upper does not fit the leg tightly, but there is sufficient room to permit the wearing of a heavy felt sock and to stuff the lower part of the Mongol's baggy trousers into the boots. The upper is soft and pliable, and is lined with coarse, thin, blue cotton cloth, resembling cheesecloth. The sole is about one-half inch thick, made up of leather and felt.

After the boot is put together, the sole is covered with a native wood oil which coagulates in drying and looks like glue, and renders the sole waterproof. On the completed boot are sewn conventional decorations in leather stripes. The amount of decoration on a boot is an important factor in the cost. The tip is tilted by a wooden last. The work on a boot is done wholly by hand. After all the materials are cut, the different parts are sewn together by hand; a worker can sew one pair of boots in two days. Prices range from about 14/- to 42/-, depending on the quality of the leather used and the amount of decoration. A pair of boots of a medium quality, with a minimum amount of decoration, sells locally for 15s. 6d.

The industry, with an average annual production of 150,000 pairs of leather boots, valued at approximately £100,000, would appear to be large enough for modernisation. A market for boot making plant could be established only if the advantages of modern machinery could be demonstrated to the local manufacturers, who are very conservative, by the actual establishment of a small plant, where workers could be trained in the use of machinery.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock:—

March 12.—Alan A. Campbell Swinton, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men." (Illustrated by Photographs.) Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., will preside.

March 19.—R. L. Robinson, Forestry Commissioner, "The Forests and Timber Supply of North America." Lord Clinton will preside.

March 26.—Neal Green, "The Fishing Industry and its By-Products." Professor E. W. MacBride, D.Sc., F.R.S., will preside.

April 2.—Sir Lynden Macassey, K.B.E., "London Traffic."

April 9.—Frank Hope-Jones, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum." Professor C. Vernon Boys, F.R.S., will preside.

April 30.—Brigadier-General Sir Henry Maybury, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "Roads."

MAY 5 (Monday).—T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MAY 7.—J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation."

MAY 14.—

MAY 21.—PROFESSOR C. VERNON BOYS, F.R.S., "Calorimetry." (Trueman Wood Lecture.)

MAY 28.—MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock:—

MARCH 21.—OTTO ROTHFELD, I.C.S., "Progress of Co-operative Banking in India."

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced:—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Monday or Tuesday afternoons at 4.30 o'clock:—

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

June 16.—C. V. Corless, M.Sc., LL.D., "The Mineral Resources of Canada: The Pre-Cambrian Area."

CANTOR LECTURES.

EDWARD VICTOR EVANS, O.B.E., F.I.C., Chief Chemist, South Metropolitan Gas Company, "A Study of the Destructive Distillation of Coal." Three Lectures. February 25; March 3, 10.

Syllabus.

LECTURE III.—MARCH 10.—The trend of developments in carbonising processes. The de-ashing of coal and other factors tending to increase the value of the therm in the form of coke.

COBB LECTURES.

Monday evenings, at 8 o'clock:—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MARCH 10 .. Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. C. E. N. Bromehead, "Natural Resources in Relation to the Arts."

Metals, Institute of (Scottish Section), 39, Elmbank Crescent, Glasgow, 7.30 p.m. Annual General Meeting. Address by Mr. G. B. Brook.

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m.

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. "The Johannine Authorship of the Fourth Gospel."

Brewing, Institute of (London Section), at the Engineers' Club, 39, Coventry Street, W., 7.30 p.m. Mr. V. B. Butt, "The Management of a Brewery Motor Transport."

Architectural Association, 34, Bedford Square, W.C., 8 p.m. Mr. H. S. G. Rendel, "The Gothic Revival."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 7 p.m. (Informal Meeting). Mr. J. T. Laspière, "On the Work of the International Conference on E.H.T. Lines, held in Paris, November, 1923."

University of London, at King's College, Strand, W.C., 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture V.)

5.30 p.m. Dr. R. W. Seton-Watson, "A Survey of Bohemian History." (Lecture VI.)

TUESDAY, MARCH 11 .. Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Annual General Meeting. Address by President.

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. R. W. Chambers, "Civilisation and Literature of the Anglo-Saxon Period." (Lecture I.)

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Prof. W. Lochhead, "The Influence of Agricultural Colleges in the Development of Agriculture in Canada."

Transport, Institute of (Graduate Section), at the Institution of Electrical Engineers, Victoria Embankment, W.C., 6 p.m.

Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Rev. E. N. B. Burrowes, "The Mythology of the Rivers of Babylonia."

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Capt. P. T. Brown, "A Note on the Air Supply to the Larger Type of the Motor Vessel."

Mechanical Engineers, Institution of (South Wales Branch), Chamber of Commerce, Swansea, 6 p.m. Dr. C. H. Lander, "Coal and Oil."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Annual General Meeting.

University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. J. W. Van Wijhe, "The Origin of the Vertebrate Skeleton." (Lecture I.)

At King's College, Strand, W.C., 5.30 p.m. Sir Bernard Pares, "Russia before Peter the Great to 1861." (Lecture VIII.)

WEDNESDAY, MARCH 12 .. London County Council, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Sir Napier Shaw, "Meteorology." (Lecture III.)
Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m. Prof. F. S. Boas, "The Byron Centenary: 'The Satires.'"
Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Mr. W. W. Paine, "A Capital Levy."
Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., 10 a.m. Annual General Meeting. 1. Address by President. 2. Paper, Mr. D. Bunting, "The Brittle Ranges in Brass, as shown by the Izod Impact Test." 3. Paper, Messrs. J. Friend and R. H. Vallance, "Determination of the Thermal Coefficients of Expansion of Some Commercial Metals and Alloys."
2.30 p.m. 1. Mr. W. E. W. Millington, and Professor F. C. Thompson, "The Investigation of a Fatigue Failure of Brass Tubes in a Feed Water Heater—with a consideration of the Nature of Fatigue." 2. Mr. Martin, "The Tensile Properties of Aluminium at High Temperatures." 3. Mr. W. E. Atkins, "The Relation between the Tensile Strength and the Electrical Resistivity of Commercially Pure Copper." 4. Mr. H. J. Wilson, "Note on the Effect of Cold-drawing and Annealing on some Electro-chemical Properties of a Low-tin Bronze."
British Decorators, Institute of, Rochdale, 7.30 p.m. Mr. T. Peters, "A Visit to Italy by a Decorator who does some Landscape Painting, illustrated by some sketches done there."
Civil Engineers, Institution of, Great George Street, S.W., 7 p.m. (Informal Meeting). 1. Mr. C. E. Stromeyer, "CO2 Recorders." 2. Mr. R. H. Parsons, "The Practical Testing of Steam Boilers."
University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. S. Hodgson, "Some Aspects of Book Distribution."
6 p.m. Prof. K. Pearson, "The Current Work of the Biometric and Eugenics Laboratories." (Lecture V.)
6 p.m. Mr. E. S. Pearson, "Birth Intervals as a Factor in the size of the Family."
At King's College, Strand, W.C. 5.30 p.m. Mr. W. R. Lethaby, "Craftsmen and Craftsmanship in Mediæval Westminster."
5.30 p.m. Prof. H. Driesch, "The Possibility of Metaphysics." (Lecture I.)

THURSDAY, MARCH 13 .. Pottery and Glass Trades Benevolent Institution, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.45 p.m. Mr. L. King, "Decoration of Glass Ware."
Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, S.W., 10 a.m. Annual Meeting continued. 1. Dr. J. Newton Friend, and J. S. Tidmus, "The Relative Corrosion of Zinc and Lead in Solutions of Inorganic Salts." 2. Messrs. E. R. Jette, G. E. Phragmén, and A. F. Westgren, "X-Ray Studies on the Copper-Aluminium Alloys." 3. Mr. F. W. Rowe, "The Effect of Casting Temperature on the Physical Properties of a Sand-Cast Zinc Bronze." 4. Mr. K. Iokibe, "Copper Zinc Alloys which Expand on Solidification."
2.30 p.m. Messrs. C. H. M. Jenkins and D. Hanson, "The Constitution of the Alloys of Copper and Cadmium." 2. Mr. D. Stockdale, "The Aluminium-Copper Alloys. Alloys of Intermediate Composition." 3. Dr. M. Cook, "The Cadmium-Lead-Zinc System." 4. M. Ishiara, "The Equilibrium Diagram of the Copper-Tin System."
Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.
Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.
Historical Society, 22, Russell Square, W.C., 5 p.m. Miss A. E. Levett, "The St. Alban's Abbey Courts and Court Rolls."
London County Council, Kingsland Road, E., 7.30 p.m. Mr. P. A. Wells, "Furniture — the Kitchen and Domestic Arrangements."
Mechanical Engineers, Institution of, Graduates (North Western Section), at the Engineers' Club, Albert Square, Manchester, 7.15 p.m.. Mr. E. Cockshutt, "Engineering Contracts."
Royal Institution, Albemarle Street, W., 5.15 p.m. Dr. J. S. Flett, "Types of Volcanic Structures." (Lecture II.)
University of London, University College, Gower Street, W.C., 5.30 p.m. Sir Frederick Pollock, "Learning the Law."
5.30 p.m. Prof. J. W. Van Wijhe, "The Origin of the Vertebrate Skeleton." (Lecture II.) 3 p.m. Signor C. Pellizzi, "Galileo Galilei."
At King's College, Strand, W.C., 5.30 p.m. Dr. A. R. Pastor, "Spanish Mysticism." (Lecture III.)
5.30 p.m. Prince D. S. Mirsky "The History of Russian Literature." (Lecture VIII.)
5.30 p.m. Mr. J. W. Headlam-Morley, "The History of the word State; its Various Meanings."
At St. Mary's Hospital Medical School, Praed Street, W., 5 p.m. Prof. B. J. Collingwood, "Blood." (Lecture IV.)
At St. Thomas's Hospital, Albert Embankment, S.E., 5 p.m. Dr. J. A. Murray, "Cancer." (Lecture IV.)

FRIDAY, MARCH 14. .. London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. E. B. Chancellor, "Royal Residences in London — Past and Present."
Royal Institution, Albemarle Street, W., 9 p.m. Dr. J. W. Mackail, "The Pilgrim's Progress."
Mechanical Engineers, Institution of (Midland Branch), The University, Birmingham, 7.30 p.m. Lieut.-Col. E. K. Clark, "Literature and Engineering." (Graduates Annual Lecture).
(North Western Section) in the Memorial Hall, Manchester, 7 p.m. Mr. O. Smalley, "Modern Foundry Practice."
Photographic Society, 35, Russell Square, W.C., 7 p.m. Lantern Lecture.
Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.
Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W.
Physical Society, at the Imperial College of Science, South Kensington, S.W., 5 p.m.
University of London at King's College, Strand, W.C., 5.30 p.m. Prof. R. W. Seton-Watson, "The Rise of Nationality in the Balkans." (Lecture VIII.)
5.30 p.m. Prof. H. Driesch, "The Possibility of Metaphysics." (Lecture II.)
At Bedford College for Women, 5.15 p.m., Dr. C. S. Myers, "The Future of Psychology."

SATURDAY, MARCH 15 .. King Edward VII. Hospital Fund, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. Allen S. Walker, "Old London and How to See it."
Royal Institution, Albemarle Street, W., 3 p.m. Prof. Sir E. Rutherford, "Properties of Gases in Vacua." (Lecture II.)
London County Council, at the Horniman Museum, Forest Hill, S.E., 3.30 p.m. Mr. C. N. Bromehead, "Links between Geology and Art."
Metals, Institute of (Local Section), University College, Swansea, 7.15 p.m. General Discussion.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.

NOTICES.

NEXT WEEK.

WEDNESDAY, MARCH 19th, at 8 p.m. (Ordinary Meeting.) R. L. ROBINSON, Forestry Commissioner, "The Forests and Timber Supply of North America." LORD CLINTON, Forestry Commissioner, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 5th, 1924; LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Arnold, James Ernest, F.R.G.S., London.
Bethell, Lieut.-Colonel L. A. B., Landi Kotal, N.-W.F. Province, India.
Bhatia, G. R., Dehra Dun, India.
Hall, A. G., Assoc.M.Inst.C.E., Landi Kotal, N.-W.F. Province, India.
Raley, Captain George Giles Emsley, B.A., M.C., Toronto, Canada.
Roberts, Lieut.-Colonel Sir James Reid, C.I.E., F.R.C.S., London.

The following candidate was duly elected a Fellow of the Society :—

Bone, Stephen, London.

A paper on "Building and Decoration of the War Cemeteries" was read by MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.M.G., C.B.

The paper and discussion will be published in a subsequent number of the *Journal*.

CANTOR LECTURE.

MONDAY EVENING, MARCH 10th, 1924, PROFESSOR HENRY E. ARMSTRONG, F.R.S., in the Chair. MR. EDWARD VICTOR EVANS, O.B.E., F.I.C., delivered the third and final lecture of his course, "A Study of the Destructive Distillation of Coal."

On the motion of the CHAIRMAN, a vote of thanks was accorded to MR. EVANS for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1924 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 22nd, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce."

The list of those who have received the medal since its institution in 1864 was printed in the last number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 20TH, 1924.

SIR STANLEY BOIS in the Chair.

THE CHAIRMAN said that Mr. Burgess was a gentleman who had gone out originally to the Straits as Government Analyst, but soon after the rubber planting industry started there he had left the Government service and had gone in for planting. Therefore the audience had in Mr. Burgess that somewhat unusual combination of the scientific and the practical. It was a pleasure to think that Mr. Burgess had brought his research work to bear on so many problems connected with the rubber industry, and, as Chairman of the Rubber Growers' Association, was now doing so much to forward its interests. The subject of the paper was of exceeding interest to the rubber industry at the moment, because that industry looked to new uses and to extended uses of rubber to absorb the large amounts which now represented the potential

production of the plantations in the East. Personally, as Chairman of the Propaganda Department of the Rubber Growers' Association, everything which would tend to increase those uses and to find new uses for rubber was naturally of the deepest interest to him.

The paper read was :—

NEW USES FOR RUBBER.

By P. J. Burgess, M.A., F.C.S.
(Chairman, Rubber Growers' Association.)

There is a cheerful proverb which says, "Sweet are the uses of adversity," though few of those who have so recently been passing through the hard and perilous times of adversity in rubber production will subscribe to this optimistic view.

One use of adversity has, however, been clearly seen in the development of many new uses for rubber, extension of existing uses, and an extraordinary development of the technique of rubber manufacture.

As recently as five years ago, all rubber went into public use and consumption through the orthodox and well-known channels of vulcanisation by either the hot or cold cure of dry raw rubber.

During the last five years the use of rubber milk or latex without preliminary coagulation has been applied to paper-making and to fibre impregnation; the direct vulcanisation of such latex and its subsequent coagulation into a fully vulcanised product have been developed. We have seen the direct use of coagulated dry but unvulcanised raw rubber, the use of gels of raw rubber dispersed in rubber solvents for direct moulding of rubber goods, of novel forms of gas curing and gas expended rubber and many fresh uses to which these, as well as rubber cured by orthodox methods, have been put.

It will be my pleasant duty to-night to give some account of these developments, and I have the privilege of being able to put in front of you examples which I feel sure will be of great interest to all.

The Direct Use of Latex.

Let us begin with the use of rubber milk or latex. This, as it comes from the tree, is a white mobile watery liquid, containing about 30 per cent. of raw rubber in fine suspension. The reaction of latex is faintly alkaline but on acidification, either by addition of acids or through natural changes which occur on standing for some hours, the rubber particles coalesce and coagulate into a firm mass. By the addition of substances which prevent acidification, such as 1 per cent. to 2 per cent. of ammonia, the latex can be preserved in the liquid condition, and very considerable quantities of preserved latex have been imported into this country and into the U.S.A.

In this country the chief direct use to which raw latex has been put has been by Mr. Kaye in paper-making, under the Kaye patents and process.

It is claimed that the addition of latex to the paper pulp sufficient to give one or two per cent. of raw rubber in the finished product is a direct advantage in that the rate of hydration of the cellulose fibre is accelerated and that time and power used in manufacture are therefore saved, and also that the finished product is improved, both as regards its tensile strength, its flexibility, and with larger percentages of rubber, its impermeability to water.

I have samples of papers on the table for inspection, but without accurate testing they will convey little to you I fear, as the rubber they contain is not apparent to the eye or hand, and their quality and appearance differ little from that of ordinary paper in use.

An extension of the principle to the manufacture of millboards and artificial leathers has lately been made and I have a range of these products here to-night.

It is claimed that the increased percentage of rubber to which some degree of vulcanisation has been conferred by the use of a soluble sulphide together with latex in the beater tank produces at a greatly reduced cost finished products of considerable value and enhanced strength.

Certainly, uses for the articles of which you see samples here can readily be conceived, as decorative panels, imitation leathers, etc., and in that direction some considerable consumption of rubber may eventuate, though it must be borne in mind that it is not so much the use of rubber in this direction that is novel as the manner of its introduction in the form of liquid latex.

One inventor who has in recent years devoted considerable time and attention to the direct use of raw rubber and rubber latex is Mr. Morland Dessau, and I am able through his courtesy, to show you a number of photographs of recent novelties for the invention of which he is responsible. I can

scarcely hope that appreciable inroads into the total tonnage of rubber production will be made by these devices, but they show what a suitable medium rubber is for giving human ingenuity full play.

In the U.S.A. preserved latex is being used for the direct impregnation of cotton fabric by rubber for use in tyre making. Fine cotton cords, side by side, to the number of 70 or 80, forming the woof of a fabric are run through a bath of preserved latex and on drying are proved to be fully impregnated with rubber, and also to be sufficiently gummed together to obviate the necessity for weft.

It is claimed that better and more complete impregnation of the cotton fibre can be produced in this way and that the absence of weft threads gives longer life to the fabric when used in motor tyre covers and also that such fabric renders the flat drum method of tyre carcass building satisfactory and economical. The introduction of this method is due to Hopkinson, of the United States Rubber Company, who is also responsible for the method of preparation of crude dry rubber by the spraying process, a method which holds out promise of providing a more easy preparation of a considerable range of moulded rubber goods, owing to the facility with which compounding ingredients may be more intimately mixed with the latex and precipitated with the rubber in the snow or dried spray.

The use of latex in the vulcanised condition prepared according to Schidrowitz's patents, I propose to deal with later on under the head of vulcanised rubber.

A further use of latex in either the vulcanised or unvulcanised condition in the ordinary household, holds out some hope and prospect of development, as providing an easy and effective means of applying a thick coat of adhesive rubber to fabrics. Bearing in mind the high percentage of rubber contents of such latex, viz., 25 to 30 per cent., as against the 5 per cent. of rubber in ordinary rubber solution, and the fact that the latex contains neither inflammable nor poisonous volatile organic solvents, the advent of the domestic "glue pot" of liquid latex may be confidently expected in the future.

A continental technologist, Dr. Rudolph Dittmar, of Gratz, has specially interested himself in the direct utilisation of rubber latex and promises the publication of a volume dealing with this subject in the near future.

One feature of his work which appears to be novel in character is the conversion of the usual compounding ingredients, such as resin, zinc oxide, sulphur, etc., into the colloidal condition in a Plauson colloid mill, and then mixing them in water suspension with rubber latex.

Such compound latices he claims to be of special use as proofing materials, and suggests the use of it as a preservative for any masonry which is porous in texture such as sandstones, plasters and concretes.

An extension of this idea to the impregnation of wood with compound latex in order to make it water and weather proof appears to offer points of novelty—the wood being first dried at 100°-103°C., and while still warm soaked in latex for 20 minutes and then dried.

He suggests that possibly some of the old Italian violin makers may have prepared the best of their wood by impregnating it with the latex of *Ficus*, and the microscopic detection of an elastic filling substance beneath the varnish of some old violins points to this hypothesis not being so far fetched as would at first sight appear. It will be passing strange if the subtle tones of a Stradivarius or Amato masterpiece are eventually traced to and laid to the credit of this wonderful colloid rubber.

Dittmar also makes the suggestion that tea chests in Ceylon be waterproofed with rubber latex and so dispense with lead foil. This use is one that might with advantage be experimented with by Ceylon planters who have both these products available.

Use of Crepe Rubber for Shoe and Boot Soles.

Raw rubber as it leaves the plantations in the East is almost exclusively in the form of either smoked sheet or crepe. I have samples of both these here and it is easy to see why the term crepe has been applied. The rough irregular surface clearly suggests the surface texture of crepe.

It has been found that the finest qualities of this crepe rubber possess extraordinary qualities as a soleing material for boots and shoes, being resilient and exceptionally durable. These two qualities combined with lightness, flexibility, silence and being

waterproof, have rapidly brought crepe rubber soles into popularity, and although their introduction into this country only dates from the winter of 1921, their success has been so marked that it is estimated some 2,000 tons of crepe rubber have been absorbed during 1923 for this purpose. Testimony from all sides has been unanimous in proclaiming the suitability of the crepe rubber sole for sporting purposes, golf, tennis, bowls, racquets and all games where grip on the ground and footwork are required, while for general use, such soles are practically everlasting, and certainly in durability and wear will outlast the uppers to which they are attached. The public has not been slow to appreciate these sale points, nor have the manufacturers or traders been behindhand in meeting the demand, which has also been stimulated by organised propaganda work by the Rubber Growers' Association in bringing these high service qualities clearly before the public. While up to the present time the chief demand has been for sports' shoes, the same qualities which make crepe rubber so suitable for sport also make it suitable for work, and I look forward to see this soleing material as the standard equipment for all boots and shoes and the practical elimination of the repairs bill for boots and shoes from the domestic budget. There has been found in natural plantation finished crepe rubber a material which will defeat that most destructive of all creatures in its most determined attempt at destruction—I refer to the British boy, and I picture his sadness of heart when he finds he cannot in a few weeks kick out his boots when shod with crepe rubber, to say nothing of being unable to slide on the pavement and strike sparks from metal heels. In order to obtain satisfactory results it is desirable that the crepe rubber be plantation finished. This phrase means that the only milling or heavy rolling process to which the crepe be subjected shall be that given it when freshly coagulated. If the rubber be dry and matured as when it reaches this country, further rolling and working thin sheets together to form soleing crepe tends to destroy the nerve and gristle of the raw rubber and such re-worked material is never entirely satisfactory as a soleing material. It appears probable that the reticulated network of proteid material formed during coagulation of the latex plays an important part in giving the tough gristly character to virgin crepe, and when this is once destroyed by re-rolling and mastication, the resulting product is soft, liable to spread in use, and altogether wanting in nerve. It is not always easy to tell by inspection whether specimens of rubber are plantation finished or rerolled products, but the best simple test is to cut a thin strip, and warm it and then to pull and stretch it. Genuine plantation finished crepe sole rubber will retain its elasticity, but the built up imitation will usually pull to pieces disclosing lamination, or show very inferior elastic recovery.

In the application of crepe rubber as a soleing material, the one great practical trouble has been in obtaining firm and permanent adhesion between the rubber and leather of the boot. The technical difficulties have, however, been largely overcome and in expert hands simple sticking of the leather and rubber together by a rubber adhesive has proved effective, but in the majority of cases the better and safer practice is to fix on the sole in two layers—the first thin layer next the leather sole being both solutioned and sewn to the leather. On to this thin layer of rubber the second thicker rubber sole can easily and permanently be stuck with any rubber solution.

In order to extend and popularise the use of crepe rubber soles for general wear, two things in my opinion are necessary:—

1. The retail price of such footwear must be reduced until it is equal to, or less than that of leather soled boots.

2. The fixing of the sole must be made more simple for the retail trade and artisan.

I should like to see put on the retail market supplies of suitable crepe of $\frac{1}{8}$ inch thickness, stuck satisfactorily to a thin leather or tough artificial leather backing, capable of being in turn stuck and nailed with shoemaker's brads to any leather sole, new or old, by country cobbler or handy man.

There should also be on sale in retail shops and at reasonable prices supplies of raw crepe rubber suitable for soleing of $\frac{1}{8}$ inch thickness, and more without such backing which can be used for building up a thicker sole when the basal portion has been fixed to the boot. Raw rubber can be easily and permanently stuck to raw rubber by any kind of rubber solution or even at a pinch by the plain use of

benzene or any rubber solvent, and there is no difficulty whatever for anyone in adding extra clean raw rubber to a raw rubber surface. Facilities must be provided in this way for popularising, by direct appeal to the pockets of the masses, a form of footwear which will give service at a minimum of cost, and those interested in the absorption of raw rubber must see that the talking point of cheapness and service is not obscured and rendered null and void by excessive middleman profits, such as at present stand between the sale of raw rubber at 1/6 per pound wholesale and 10/6 per pound retail.

There are many further technical points in connexion with this new use for rubber that I have not time to go into fully now, but I can recommend to your attention a little handbook prepared by the Rubber Growers' Association which gives a full account of the crepe rubber sole, and the technical points in connexion with its application.

I should like, however, to hold your attention for a few minutes to some general considerations arising from the use of crepe rubber for soleing.

Each pair of shoes soled and heeled with crepe rubber may be taken as absorbing one pound of pure raw rubber. For men's boots the figure is rather more but on the average one pound is a near approximation.

From my own experience with these soles I do not estimate that the average user will wear away one pound of rubber from his boot in a year's use, but allowing for casual loss, there will not be much error in assuming that one pound of rubber will be destroyed annually for each user of crepe rubber soles, when such soles are used for all purposes, and not merely for sports shoes.

On this basis each 1,000 tons of rubber used will mean the daily use of crepe rubber soles by 2¼ million people. It is estimated that 2,000 tons have already gone into consumption for this purpose through the usual trade channels in this country and assuming that 1,000 tons have been exported the remaining 1,000 tons here, are sufficient to equip 2,240,000 pairs of boots. Simple observation of the soles of the British Public shows that nothing approaching 2¼ million people, or one in every twelve, in this country are daily using crepe rubber soles; it is, therefore, clear that the bulk of this 1,000 tons must represent "original equipment" and that the annual replacement demand has not yet begun to be felt.

While recognising the magnitude and possibility of this new use, we must also recognise the limitations, and we are still far from tearing leather from the soles of the public's boots and putting rubber in its place.

Here too, it is only fair to consider some of the objections raised to the crepe sole, the chief of which are the liability to slip on wet, greasy pavements, and some tendency to heating of the feet on account of the waterproof nature of the material. The latter objection is more imaginary than real, and is largely prejudice based on experience with rubber overshoes, where not only the soles but the uppers as well are waterproof. Any tendency in this direction can, however, be easily met by the use of a loofah sock in the shoe. The difficulty of obtaining secure foothold on greasy pavements is a very real one, and becomes very acute when the initial roughness of the soles is worn away. Soles with recessed cavities have been recommended, but I have personally not found such recessing efficient. A satisfactory cure appears to be by renewing the ribbing of the rubber surface by cutting furrows across the soles with a sharp table knife, wetted with soap and water for easy cutting, removing the V sectioned strips of rubber and thus reforming a strongly ribbed pattern again upon the sole.

Suggestions for some inlay of leather, either in the form of studs or bars have been made, but such expedients have not become popular. In my opinion this liability to slip under wet weather town conditions is the one real objection to the use of the raw rubber sole, and this point must be met before their use can become universal. Details of colour and finish can, I think, be safely left to the practical boot manufacturer to overcome, but it is a matter for those who are largely interested in the raw rubber position to see that some cure for slipping in mud is satisfactorily developed.

It has been said that the crepe rubber sole is a "fad" and that it will not take permanent hold on the public taste. It is sad work posing as a prophet, and the only certain thing is the certainty of uncertainty. But without fear of contradiction, I am prepared to assert that the

crepe rubber sole is far superior to any other form of sole yet put on the market on the counts of extreme durability, silence, lightness, flexibility and being water-tight. I cannot say that something better will never be made, but I am sure of this—that if the better thing be made of vulcanised rubber it will have to be a very high grade mixing and contain a high percentage of rubber. The crepe rubber sole has established a standard and the public after experience with it will never again tolerate shoddy rubber composition soles which wear out in a couple of weeks and are dear at the cheapest of cut prices.

The indestructibility of the crepe sole will also have the effect of creating a large stock of crude rubber scattered in the hands, or better on the feet, of the general public, a rubber which will eventually come into the scrap market and be available without going through the reclaiming process. A similar consideration applies to all other uses of raw rubber by the general public, and the recent development in the manufacture of raw rubber mats, inlaid in various patterns and containing practically 100 per cent. pure rubber, samples of which I have here on the table, will work in the same direction because the mats will certainly never wear away in the lifetime of the user. It may well happen that such mats in time of rubber scarcity and high prices will be worth more as scrap than they are now new.

A number of other uses for raw rubber have been suggested and to some extent developed during the last year or two, as handles for golf clubs, racquets, bats, etc., but the use in these directions is very limited owing to liability of the rubber to harden and soften with cold and heat and to become tacky under the influence of sunlight. For all such purposes rubber vulcanised in some way or other is, I think, preferable, and attempts to develop the use of unvulcanised rubber in these directions are in the long run not likely to succeed.

Vulcanised Rubber.

Most prominent among the new and, indeed, revolutionary new processes is that due to Dr. Schidrowitz, in which rubber in the latex itself is converted into a vulcanised product, by the addition of sulphur or sulphur yielding substances, accelerators and fillings as required and then heated, the latex meanwhile being kept in the originally liquid state by ammonia, and other means.

While unchanged so far as its liquidity and capacity for coagulation on acidification are concerned the latex after such treatment consists of a suspension of vulcanised rubber particles, while the coagulum from such vulcanised latex is found to present all the features of fully vulcanised rubber. It is not easy to see the limit to the uses to which such vulcanised latex may be put, provided suitable machinery and technical equipment are devised for the new problems in manufacture which this new material presents. It will be interesting to consider some of the directions in which vulcanised latex has already been applied and the particular advantages associated with it.

Tyres. It is claimed that factory procedure is much simplified by the ease of control of vulcanisation of the tyre carcass owing to the elimination of the difficulties of variability of ordinary raw rubber, and the simplification of the control of the sulphur. In connexion with processes connected with tyre building, impregnation of cotton with rubber by the use of vulcanised latex is considered to be simplified and improved, whether such impregnation takes place with the cotton wool, with a fine count cotton to be subsequently cabled, with cabled cord or with cord fabric.

One most important claim, which if substantiated, must have far reaching results, is that the final product of latex impregnated cord is 20 to 30 per cent. stronger than cord rubber proofed in the ordinary way. This improvement in strength would allow a cheaper grade of cotton fibre to be employed, and would go far towards solving the problem of a shortage in the world's supply of first quality cotton. A new and improved method of manufacture of waterproof string, cord and ropes for all general uses, both old and new, is similarly opened up. Proofing fabrics by liquid vulcanised latex is claimed to be cheaper, and to give new effects, and to be capable of use when ordinary rubber proofing methods cannot satisfactorily be applied and in this sense the process of Dr. Schidrowitz may be regarded as a new use of rubber.

In this way too, rubber can come into direct competition with oil for fabric proofing, the process being superior in points of speed, being continuous in action, giving a product free from smell, less tearable,

with no tendency to deteriorate in the manner characteristic of oiled products, a much longer life and capable of being easily repaired. Claims are made that for use in paper making vulcanised latex is as well adapted as raw latex, and also that the finished product is better. There would appear to be some new uses for vulcanised latex in connection with building operations in the form of distempers, roof compounds, brick waterproofing, with cements and floorings.

As an adhesive for joining wood, leather or fabric to rubber its use may be very extensive, and in this connexion there is an interesting new use for vulcanised latex in bill-posting. This medium by rendering the paper fabric of the advertisement waterproof and being itself a waterproof adhesive gives long life to the poster and any extra cost of vulcanised latex over bill posters' paste is repaid by the durability of the work. Results have shown that posters fixed in this way are good for at least six months' display, in any type of our winter weather.

For rubber sheet of all kinds for solid and dipped rubber goods it is claimed that vulcanised latex is fully adapted and gives products which are odourless, and have longer life and ageing qualities, and in general are much less liable to failure from errors in curing owing to the greater ease of control of the free sulphur and practical elimination of all free and uncombined sulphur from the finished products.

Through the courtesy of the Vultex Products Ltd., I am able to show you a large range of products made from vulcanised liquid latex.

With rubber compounded and cured by old and well known methods there are every week new uses being suggested and developed.

It is only necessary to turn over the pages of the rubber trade journals or to study the rubber patents files to appreciate the mass of new development of rubber use which is day by day permeating the whole industrial world. One of the most recent developments and one which promises, I consider, to be a big consumer of raw rubber in the future is in the better springing of road vehicles by the elimination of the metal shackles and bolts which support and control the ends of the usual leaf spring and replacing them by rubber shock insulators. In this new method of construction the ends of the springs are imbedded in rubber blocks which are held under compression in metal casings rigidly attached to the frame of the vehicle. In this way a second line of rubber defence between road shock and the vehicle is provided, and not only is obtained additional comfort in riding, but noise and rattle from loose shackle pins and metal to metal contacts are eliminated.

It will be noted that there is no movement nor friction between surfaces, but the rubber provides an elastic bed for the movements of the spring ends. These shock insulators do away with shackles, bolts, nuts, bushed and hardened surfaces, machinery and fitting, and, what would appeal strongly to the owner driver of a car, eliminate once and for all grease caps and oil from spring ends. In the U.S.A. these shock insulators are in use on light motor cars as well as on heavy buses. The new Mack bus, weighing 9,480 pounds or rather over 4 tons, is equipped with these shock insulators at the ends of all springs, and the builders of the 5 ton Mack lorry give testimony that at the end of 50,000 miles of running, no wear can be shown in the rubber blocks. Looking at this development from the point of view of the consumption of raw rubber, the amount of rubber in a set of these shock absorbers may be taken as the equivalent to the rubber in a single tyre. While this would imply for original equipment a consumption of rubber which would run into approximately 4,000 tons for 1,000,000 passenger motors, if the claim of longer life to tyres in consequence of shock reduction be substantiated, the total consumption of rubber might, in the long run, be actually reduced.

Another and totally different recent development is in connexion with crushing and grinding mills, in which the material to be ground is enclosed in a revolving tubular vessel with a number of heavy iron balls. Until recently the linings of these tubular vessels or tube mills, were of thick iron or steel plate. It has been found that this iron plate can be advantageously replaced by a rubber lining which not only resists the wear and tear of the rocks and iron balls better than did the metal lining, but it is also found that grinding takes place more rapidly and more perfectly. This curious and unexpected result is probably due to the rubber walls of the mill as it revolves gripping the heavy iron

balls better than the metal lining, lifting them higher without slipping and eventually letting them fall with greater effect upon each other and the material to be pulverised.

There has just been sent to Canada, for use in a tube mill, the first liner built up of crude crepe rubber instead of vulcanised rubber. The liner measured ten by four feet, and was one inch thick, weighing 205 lbs.

ROAD SURFACES AND PAVING. For many years efforts have been made to use rubber compounded and vulcanised as the surface material for roads and pavements, and recently the very low price of raw rubber has stimulated efforts to find extended use of the material in this direction. The advantages of its use are fourfold—absence of vibration, silence, durability and non-skidding. The difficulty now appears to be to find a really satisfactory method of application. Road surveyors favour blocks of about 9″ × 4½″ × 3″, of which the upper wearing surface is a high quality compound. This size is thought to be most suitable for laying, taking up, patching, etc. The trouble in the past had been to obtain a satisfactory adhesion of the rubber layer to the base of the block, though this appears to be now solved by the blocks used by Rubber Roadways in the Borough High Street, Southwark, a small strip in Holborn and in the latest area round the Cenotaph in Whitehall. The "Cresson" block manufactured in Singapore is also reported to be efficient in this direction. The adhesion of the soft resilient rubber surface to the rigid hard base of the block is in both cases effected by direct vulcanisation and is rendered possible by the base of the block containing a certain proportion of rubber.

The most suitable shape, size, and form of block for laying so as to prevent creeping, lifting and loosening of the blocks with traffic and making the jointing watertight is the problem which cannot be said to be satisfactorily or finally solved so far. I cannot help feeling that the road engineer in this case has been dominated too much by the ideas of size and shape which were suitable, nay, almost necessary, in the case of wooden blocks where any large increase in the size of the block would entail relatively much larger cost, and difficulty in obtaining suitable wood from which they could be cut. This consideration does not apply to a manufactured rubber block, and it would seem that the use of rubber blocks in very much larger and heavier individual units would give equivalently greater adhesion to the road bed, fewer joints and generally greater stability. I am very strongly of the opinion that a road surface built up in this way from large blocks would overcome the remaining difficulties of rubber road construction, and consider that some trial should be made in this direction.

It is not, however, to the white races alone that the utilisation of rubber in novel ways is confined. The Chinese have for long been famous as an ingenious race, and though the new use I am about to introduce to you is not a case of "Ways that are dark and tricks that are vain" yet it is clearly a case of "Chinese is peculiar." A firm in Singapore, Messrs. Chin Seng Hin and Co., have concocted and put on the market a rubber compound which when softened by heat and spread on a board will like birdlime snare the unwary bird, beast or insect which may cross the too hospitable threshold. Rats and mice stick to it closer than a brother, and the trouble I understand is not so much getting them on to it as getting them off again.

A use of rubber by high art concealed from the public, but at the same time flaunted in their faces when they go to the "pictures" lies, in both senses of the word in the manufacture of theatrical properties for motion picture production.

Rubber sharks and octopuses add to the tragedies of marine disaster, prehistoric monsters puncturable by a bodkin, swords, battle-axes, maces and all the paraphernalia of the rousing cinema battle are made of harmless rubber and a rubber uddered cow gives milk, or some other substitute in unlimited supply.

A new form of rubber termed Onazote consists of rubber expanded into a spongy condition by gas under pressure, but differing from ordinary rubber sponge in that the cavities are unbroken, and remain filled with gas under pressure. The rubber itself is vulcanised and according to the degree of vulcanisation, the resultant product is either a soft resilient substance or a hard expanded vulcanite.

Owing to the extreme expansion which the material undergoes in the special process of manufacture, a product of extraordinarily low specific gravity can be obtained, and furthermore the gas cavities being unbroken and discontinuous,

the material acts as a highly efficient non-conductor of heat. When the material was first shown to the public at the Rubber Exhibition at the Agricultural Hall in 1921, great hopes were entertained of its future use, for it does undoubtedly possess qualities which are unique and if it can be prepared in bulk at a reasonable price, there are numerous uses to which it is specially adapted. From the point of view of the producers of raw rubber these hopes have so far failed to materialise.

I have samples on the table of this rubber curiosity, and uses such as floats, shock absorbing cushions and insulators for ice chests and cold storage plants on the large scale are quite obvious from a simple inspection of the material.

PROPAGANDA.

In bringing this paper to a conclusion I realise how totally impossible it has been for me to do justice to the subject of new uses for rubber, not from lack of material but from the profusion of it. Truly it is a case of "not seeing the wood because of the trees."

Rubber is a material which has remarkable properties peculiar to itself, which is capable of conversion by suitable compounding and vulcanisation into materials of such wide range of character and function from elastic thread capable of tenfold extension, to hard tough ebonite taking a fine polish and worked as readily as ebony its prototype, from a spongy foam, the lightest of all solids—built up of cells that imprison self-expansive gas, given us by nature as a milk, a colloidal water emulsion, finer and more perfect than any artificial product.

Rubber is the handmaiden to all modern arts and crafts, transport by land or sea or air is made safe and easy by its means. In truth it seems to me a harder task to find a field of work or play in which rubber does not take its necessary place and share than it is to find a needle in the haystack. In spite of this multiplicity of uses, it must be recognised that rubber in most instances is in use as an adjunct, in a subordinate capacity, as a component part but not the principal or bulkiest component. In road transport tyres of rubber are far and away the best, but they represent only a small part of the road vehicle. So far in the thousand and one articles in whose existence rubber plays a part it will be found that rubber is mostly an accessory—the air brake tubing of the train, the washer in the tap, the cushion of the billiard table, the proofing of the mackintosh.

The world in the last four years has seen a bigger supply of rubber produced than it has been able to consume. To fit consumption to production by developing new uses has been the aim of growers of the raw product, and the Rubber Growers' Association in 1919 organised a competition in which prizes were offered for suggestions for new uses for rubber.

The competition was given the widest publicity and over 2,000 individuals sent in some 10,000 suggestions, which covered a very wide range of subjects and certainly embodied many new ideas. These have all been collated and are now published in a classified form for reference and use, but no outstanding suggestion for any practicable new use of rubber in bulk was put forward. That the use of rubber was stimulated and invention hastened by this campaign I have no doubt whatever, but the general result shows that bulk consumption of rubber for existing uses must follow the development of industry and civilisation as a whole. There is no close or direct relation between the world's capacity for production and consumption, and the collapse in 1921 and 1922 of the price of raw rubber to far below the figure at which substitutes and reclaimed rubber were an economy in manufacture did not seem to lead to greater bulk consumption. What the rubber producing industry needs, and what I have been actively seeking for many years is a use for rubber on the big scale which will function as a practicable proposition with raw rubber at some pivotal price, say 1/6 per lb. In seeking a cure for over-production it is little good turning to the development of any use of rubber if it merely fills the role of accessory or small percentage component of some other article, but it must be on the lines of an article where the chief bulk or cost is rubber that the cure for the evils of over-production must be sought, and where the manufacture and use of it will only be an economic proposition with the price of raw rubber at or below some fairly well defined pivotal figure.

A use for rubber of such a character as this would play the part of an efficient fly-wheel or governor in the conomic machine, lifting dead-weight of excess

production from the market and being cut out or ceasing to function when there occurred a pronounced demand for rubber from other directions, and when prices rose in consequence.

To find such a use is the rubber problem of the day to which all other problems and difficulties in the rubber world are secondary.

I can tell you where the solution to the problem will not be found. It will not be in rubber soles. They may absorb the present surplus, if any now be left; they may in future account for some potential surplus assuming full production in force from existing sources of supply, but their use or disuse will not depend upon any pivotal price of raw rubber, the cost of the rubber on the shoe being but a small factor in the price of the shoe itself. It will not be found in the trade in small rubber sundries—in surgeon's gloves or aprons—in rubber acorns for window blinds or rubber stops for doors. Though the whole world combine to make mistakes the use of india rubber for erasion of them will still be a feather in the scale.

Tyres, which now consume seven-tenths of all the rubber produced are made and worn away with little reference to the balance of supplies of rubber, or of cotton or of oil.

The one direction in which I see a gleam of light by which this problem may be solved points down a broad but silent road. I see rest for tired feet, repose for jangled nerves, speed in security for restless passengers along that highway paved with the trickle, the tide or the flood of rubber brimming over from nature's generous forest spring. That may be the golden age when the streets of the great cities are paved, with gold? No! With rubber.

DISCUSSION.

The Chairman (Sir Stanley Bois) confessed, as one deeply interested in the greater consumption of rubber, that the general effect of the paper had been somewhat depressing to him. Mr. Burgess pointed out what was undoubtedly very true, namely, that the extreme durability of the product was calculated to militate very seriously against its extensive consumption in the matter of footwear. Those who had been seriously affected by the slump in prices which had occurred in 1921-22, realised that a weak feature in the position of the industry was its very great dependence upon the motor trade for the main consumption of its product, the motor trade consuming some 70% of the whole output. The enormous improvement which had resulted from the substitution of cord fabric for the old fabric used in building up the body of the tyre, and the consequent much greater durability of the tyre had precluded that extension in the use and actual consumption of rubber which might otherwise have taken place. He was bound to say that he thought to that fact was to be traced a good deal of the lack of demand which had been experienced for increasing supplies.

With regard to the use of crepe rubber soles, their great value for sports purposes had been sufficiently demonstrated; and he thought there would be seen an immense extension of the use of crepe rubber soles for ordinary footwear. It might be of interest to the audience to know that the Propaganda Department of the Rubber Growers' Association had now an experiment in progress in that connexion. They had equipped some 50 postmen in Scotland, who had a long daily round, with crepe rubber-soled boots, which could be sold at competitive prices with ordinary leather-soled boots. The Department were now awaiting the return of some of those boots after the first three months' wear. They were also looking to the return of a further lot after six months wear, and further lots subsequently, so that they might get a really good test of the durability of the boots for that particular purpose.

Dr. H. P. Stevens said that, although Levea latex had been available for the last 15 years, until comparatively recently, nobody had used it; but rubber manufacturers, particularly in the United States, had now realised the potentialities of rubber latex, and were taking steps to obtain benefit therefrom.

He would like to make a criticism with regard to the addition of mineral and other ingredients to latex with a view to manufacturing for the preparation of raw rubber containing those ingredients. Reference had been made in the paper to the Hopkinson process, and it was stated that the method "holds out promise of providing a more easy preparation of a considerable range of moulded rubber goods, owing to the facility with which compounding ingredients may be more intimately mixed with the latex, and precipitated with the rubber in the snow or dried spray." Personally, he did not see why there should be any greater facility in the preparation of rubber goods by that process than by the ordinary processes at present in use. Whether one sprayed or coagulated the latex, one had to add mineral ingredients, and the methods adopted would be the same in both cases. A number of experiments had been made by adding mineral ingredients to latex and coagulating it, and one undoubtedly did get a raw rubber in that way which contained the mineral and other ingredients very uniformly distributed throughout the mass. The difficulty, however, which he had found was that directly one got

appreciable quantities of finely-divided mineral ingredients, like china clay, into a mass of rubber which had been coagulated and unworked, the rubber so obtained was so hard that it could not be broken down and used for mixing in with other rubber for the purpose of the manufacture of rubber goods.

The author spoke of the United States Rubber Company as being responsible for the method of preparation of crude dry rubber by the spraying process. He did not desire to enter into the question of priority, but there were two or three other spraying processes in the field.

Mr. B. D. Porritt said his first thought on listening to the paper had been that there was really nothing new under the sun, but that was perhaps incorrect, and the true inference to be drawn was that a long period usually intervened between the making of a suggestion and its being brought into practical use.

In considering the question of the direct employment of latex, one had to go back almost to prehistoric times, when this was originally used by the natives for waterproofing their garments.

In the early days of manufacture in Great Britain, when Thomas Hancock started work, the initial problem was the supply of solvents, and practically the first thing which Hancock did was to investigate the possibilities of latex. His second and third patents dealt with the direct use of latex, in the first case for the manufacture of a leather substitute, and in the second case for the preparation of ropes and cordage. The difficulty which arose in those days, and which had prevented any practical application being made of these patents, was the fact that it was then impossible to import latex without fermentation.

In Hancock's book it is stated that in 1852 an American discovered the use of ammonia as a preservative, and Hancock describes various experiments which he made in connexion with the subject after that date.

With regard to the use of crepe rubber for soling, in his first patent in 1820, Thomas Hancock claimed the use of sheets of rubber cut from the "bottles" of Para for boot soles.

Emphasis has been recently laid on the importance of using only plantation-prepared crepe for soling. Personally, he would not like to express any definite opinion on this point, but he was inclined to think that the material manufactured at home from standard plantation crepe, would be found to be a quite satisfactory product, and, indeed, he very much doubted whether this could be differentiated from that prepared on the estates.

Mr. Walter C. Hancock said it was with a great deal of diffidence that he ventured to make any remarks on the subject of rubber, because it was only by reason of his family connexion that he had any right to speak on the matter. The first impression produced by the author's paper, so far as the extended use of the raw material was concerned, was a somewhat disappointing one. He entirely agreed with the Chairman that one of the inherent difficulties in the whole subject was that the durability of rubber was itself, from the rubber producers' point of view, its great drawback. The only extended use which he could see for the use of rubber at the present time was in its application as a road material. Its use as rubber soles was distinctly limited. Mr. Porritt had already referred to the work of his great-uncle. On looking back on the history of the manufacture of rubber, it was rather strange that 100 years after Thomas Hancock's original patent had been taken out there were practically no new uses for rubber, excepting those which had very largely arisen from the development of new and fresh industries which had been unknown in Thomas Hancock's day. It was the development of industries throughout the world which would probably lead to an increased consumption of rubber.

Mr. M. S. Parry remarked that everybody seemed extraordinarily pessimistic, but his belief was that if all connected with the rubber industry did their utmost and proceeded on the right lines, they would be just as successful now and in the future as they had been in the past. Everybody who had spoken had overlooked the fact that we had just gone through a very big war, and that the whole world was topsyturvy. When the world ceased to be topsyturvy his own belief was that the various uses of rubber and the new uses of rubber would have a very great effect throughout the whole of the Continent. He congratulated the Propaganda Department on the excellent work it had done and was doing, especially in drawing attention to the advantages of rubber for soling boots. For the same reason that America used so much rubber owing to the snow, so, he believed when Russia got on her feet again, she, in turn, would buy rubber in order to sole boots. In order to consummate the excellent work of the Propaganda Department, he thought the Rubber Growers' Association should go one step further and create a consultative body, which should follow up the work of the Propaganda Department, and supply all possible information to those various countries as to how to obtain rubber soles, where to put them on, etc. We had had a great deal of difficulty in learning that even in this country. He therefore suggested that some sort of organisation as he had suggested should be set up, and which should embrace everybody who had experience in the matter, even the bootmaker. In that way the uses of rubber soles would be enormously extended. He urged, also, the rubber companies to put before their shareholders the desirability of wearing nothing else but rubber-soled footwear.

DR. RUSHTON PARKER asked if everything possible had been done to treat india-rubber in such a way as to make it withstand sea water, so that it might supplant gutta-percha for submarine cables. Was it conceivable also that any plan could be invented by which the surface of stone buildings in London might be treated with some kind of preparation of india-rubber so as to save places like the Houses of Parliament?

MR. R. à-ABABRELTON said in this country what political people required at the present time were new houses. But we were told there was a shortage of bricks. The author had referred to the use of rubber bricks in road-making. Was it at all possible to manufacture rubber bricks which could be used to build houses? Could not the Propaganda Department make experiments so that eventually rubber houses in some form or another might be erected in this country?

The author had stated that rubber was useful in connexion with roofs. In South Africa and other tropical countries galvanised iron, zinc and such metals were used for roofs. The result was that the rooms became tremendously hot. Was it possible to substitute a roof made of rubber for a roof made of galvanised iron in such countries?

MR. H. E. MILLER (Vice-President, Rubber Growers' Association) said that the planting of rubber had been conducted very largely by British enterprise, and yet a surprisingly small proportion of the use and manufacture of rubber goods was carried out in this country. Previous speakers had stated what a conspicuous part British scientists had played in inventing new uses for rubber and the best means of treating it, and he was quite sure there were many brains to-day thinking out possible developments and new uses of rubber. He was not a pessimist. He was certain that in this country there were men of science and practical men who would in one way or another invent new uses for rubber, which would re-establish the plantation industry, and give the world the benefit which it would undoubtedly derive from every new application to which rubber was put.

There was no doubt that rubber was the very best road surface. The problem, however, which had yet to be solved, was how to keep such a road water-tight. Whether "Vultex" or anything else was going to solve that problem or not, he did not know, but if everybody would focus his attention upon it he was convinced that before very long rubber would be used in extensive quantities for road paving purposes.

MR. D. F. L. ZORN said he had had the privilege of sitting under the Chairmanship of Sir Stanley Bois on the Propaganda Committee of the Rubber Growers' Association for some considerable time past, and he desired to say that when Sir Stanley accused himself of being a pessimist on the question the audience were not to believe him. Sir Stanley perhaps might express verbally a little pessimism, but he could inform the audience that the amount of work which he had done in the way of propaganda to bring about increased uses of rubber was simply tremendous. He could only wish that there were more such men in the industry. The same was true of Mr. Burgess. Those two gentlemen were much too modest to state what they were doing themselves, and he had, therefore, felt it incumbent upon him that he should make the information known.

Mr. Porritt struck a very correct note when he said that there was a long interval between ideas first being thought of and being brought to practical application. It was interesting to note that the direct employment of latex had been thought of 100 years ago. He thought it would be found in very much less than 100 years hence that the direct employment of latex would be a thing which would bring about an enormously extended use of rubber. There had been an interesting article in an American journal on that point, in which the writer had pointed out that the use of latex was likely to be found very valuable indeed in industries which, up to the present, had never been associated with rubber in anybody's mind. The writer had given one or two illustrations of that. One was the substitution of latex for what were known as the drying-out oils, such as linseed oil. It was pointed out in that article that in such directions as those there were tremendous openings for the direct use of latex. Personally, he thought that what would probably happen would be that before very much longer there would be found developing side by side with the old rubber industry another series of industries, all of them occupied with the direct employment of latex, which would demand vast quantities of rubber. From the point of view of the rubber planter or producer, it really did not very much matter whether rubber was used as latex or whether it was coagulated and used as rubber.

MR. MORLAND M. DESSAU said the use of rubber for roadway purposes had been retarded on account of the work hitherto done proving unsatisfactory. He himself believed that such a difficulty was easy of solution. In order to obtain a perfect rubber roadway it was necessary, to his mind, to have competent bodies examining and reviewing plans which various inventors had for the laying of a roadway. He suggested that the Rubber Growers' Association should establish a competent body to review the different methods of roadway construction. He himself had seen several different systems of varying degrees of merit. One great difficulty was in getting a water-tight roadway, but such

a difficulty was not insurmountable. He was afraid that up to the present time those who had been trying to solve the problem had received but very little encouragement, on the ground that there were no funds available by which to carry out experiments. Personally, he should have thought that those interested on the planting side could well afford even to squander a considerable amount of money, in order to try out the various schemes until they had found one which was successful. Even if 99 schemes proved to be failures, if the hundredth proved to be a success, the outlay would have been more than justified.

The Author, in reply, said it had been very far from his intention to have cast a gloom over the assembly. He was an absolute optimist as to the future of rubber. All he had desired to do was to focus attention on new uses for rubber in bulk. At present rubber always appeared as a little piece of something else. There were many things in which ounces of rubber were used, but practically none in which thousands of tons were used, other than in tyres.

As to getting shareholders to consume rubber, there were a quarter of a million shareholders. If each one of them used up 10 lbs. of rubber a year, that was about 3 or 4 ounces a week, and they would find themselves hard put to it to destroy 4 ounces of rubber a week; but supposing each shareholder did use up 10 lbs. of rubber a year, it would amount to 1,000 tons; and, as against that, a few years ago there had been dumped in this country an excess production of 40,000 or 50,000 tons in the year. Of course, every little helped, and he did not minimise the effect of the extension of small uses of rubber; but it had to be remembered that 70 per cent. of the world's rubber was used on motor-cars at the present time. If they could extend the use of motor-cars then more could be done for the extension of the use of rubber than in any other way, but the Rubber Growers' Association had felt that to deal with the extension of the use of motor-cars was really entirely beyond its province.

Dr. Stevens had referred to the question of the facility which Hopkinson found in making moulded goods from his snow. He thought the point was as follows. When the stuff fell to the bottom of the settling chamber, Hopkinson obtained a material which was about eight inches thick. When it was put under hydraulic pressure it came down to a slab of about 1½ inches thick. It was during the compression of that dry material that Hopkinson found the facility of forming moulded goods. If Hopkinson was able to get his snow made up of rubber compounded with the materials he required, then moulding could take place from the snow itself. He thought that was the point—that there was no need for breaking up by mastication before the moulding took place.

Dr. Stevens asked how Hopkinson vulcanised the moulded goods.

The Author replied that he vulcanised them after they were compressed. He moulded them and vulcanised in the mould.

With regard to the question of the use of rubber for submarine cables, he did not anticipate that rubber would ever quite oust gutta-percha. It was a different gum altogether.

With regard to the use of rubber bricks for building houses, it had to be remembered that bricks made of rubber, or bricks used for roadways, cost something like 2/6 a piece, and if people had to buy bricks with which to build houses at 2/6 a piece they would have no income left with which to live.

There might be certain uses for rubber in connexion with roofing, perhaps in some artificial or composite roofs. If, for instance, the expanded rubber "Onazote" could be prepared cheaply on a large scale, it would be a splendid substance for putting underneath the galvanised iron roofs used in tropical countries, because it was such an excellent non-conductor of heat or cold. One of the big uses suggested for it was for lining refrigerating rooms, where it was essential to keep the heat out or to keep the cold in.

Mr. R. à-Ababrelton asked if there was any chance of such a rubber melting on account of the tremendous heat experienced in tropical countries.

The Author replied that the rubber would not melt if it had been vulcanised.

A hearty vote of thanks was then accorded to the lecturer for his interesting and valuable paper.

Mr. J. Fairbairn said he was sure the audience would not like to depart without according a cordial vote of thanks to the Chairman. It had been said that Sir Stanley devoted a certain amount of time to the Rubber Growers' Association. Personally he had sat on the Propaganda Committee, and he had often wondered what amount of time Sir Stanley gave to his own business. In fact, he had come to the conclusion that either Sir Stanley was a very wealthy man or an extreme enthusiast. Greater enthusiasm was needed from those at the head of affairs. There must be greater pooling of interests and greater combination. He had no doubt that if they all stood together and worked together and fought together, big new uses for rubber would come along.

The vote of thanks was carried unanimously.

The meeting then terminated.

OBITUARY.

ALBERT FRANCIS WENGER.—Mr. Albert Francis Wenger, who was elected a Fellow of the Royal Society of Arts in 1919, died on February 25th, in his 87th year. He was born at Lausanne, and as a boy he went to the factory of an uncle in Milan, a well-known pottery manufacturer. He became manager of the firm, but subsequently set up in business on his own account in Naples. In 1862 he visited London at the instance of the Municipality of Milan, to report upon the ceramics shown at the Exhibition. On this occasion he visited the Staffordshire potteries, and became so much interested in them that he decided to settle there. This he did in 1869, beginning as a modeller for the Worcester and other factories. He then started colour-making on a small scale at Cobridge; later he moved to Hanley, and in 1900 the present large works were built at Etruria. At his factory, he had a valuable collection of historic ware, from Egyptian days down to the present time; and at his home he had a large collection of prints and pictures. He was both a practical potter and a connoisseur, and he was one of the most able and remarkable men in the pottery trade. He introduced numerous improvements in pottery manufacture, including vaporisers for spraying colours on to the ware and liquid gold. Before the War his was the only firm that manufactured liquid gold in England. He was also the first manufacturer of lustres in England.

SIR JOHN STEWART-CLARK, BT.—The death took place on March 3rd of Sir John Stewart-Clark at his residence, Dundas Castle, Midlothian. Born in 1864, he was educated at Merchiston Castle School, Edinburgh, and Jesus College, Cambridge. He succeeded to his father's interests in the great thread combine of Coats and Clark. A man of great wealth, he contributed large sums to charitable objects, and was on the boards of various hospitals and similar institutions. He was a member of the Royal Company of Archers, King's Bodyguard for Scotland. A baronetcy was conferred on him in 1918.

Sir John was elected a Life Fellow of the Royal Society of Arts in 1913.

GENERAL NOTES.

FORMOSA.—Dr. T. Baty in a recent issue of the *Contemporary Review* gives us an attractive picture of this far eastern centre of sugar and camphor production. "If a European were suddenly set down in Taihoku and invited to guess where he was, Formosa is the last place that would occur to him. We think of the island as it was thirty years ago—a 'nooks-hotten' place of sugar shanties and hovels fringing the virgin mountains......., the great solid palaces marble-lined, the well paved roads, the villas and hospitals. Little is known in the West of the energy and enterprise with which the Japanese have set to work to create modern conditions in their new possessions." Askao (now called Heito)—one of the smaller towns—is an important sugar centre with the central factory of the Formosan Sugar Company. The big camphor works are at Taihoku, and travelling into the hills by the Arisin scenic railway one sees the forests which are the source of much wealth. Formosa has more than half a million acres of rice lands. The first crop for 1923 was nearly 13 million bushels.

THE ESTHONIAN GLASS INDUSTRY.—According to information received by the Esthonian Central Statistics Bureau, approximately 386.3 tons of window glass and 1,500,000 bottles and glass articles were manufactured in Esthonia during 1922. The glass factories were closed down during the war. In 1919 and 1920 the Jarvakandi factory was the only one working. In 1921 three were in operation, which in 1922 had increased to four. The following glassware was imported in 1922: Bottles and jars, 626.6 tons; window glass, 478.8 tons; mirror glass, 19.1 tons; other glassware, 507.2 tons. The total output of the Esthonian glass works is consumed in the country, and still a great deal of glass is imported. This seems to show that there are big possibilities for extending this branch of industry in Esthonia.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock:—

MARCH 19.—R. L. ROBINSON, Forestry Commissioner, "The Forests and Timber Supply of North America." LORD CLINTON will preside.

MARCH 26.—NEAL GREEN, "The Fishing Industry and its By-Products." PROFESSOR E. W. MACBRIDE, D.Sc., F.R.S., will preside.

APRIL 2.—SIR LYNDEN MACASSEY, K.B.E., "London Traffic." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

APRIL 9.—FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum." PROFESSOR C. VERNON BOYS, F.R.S., will preside.

APRIL 30.—BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "The London Dock District and its Roads."

MAY 5 (Monday).—T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MAY 7.—J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation." ADMIRAL OF THE FLEET SIR HENRY JACKSON, G.C.B., K.C.V.O., F.R.S., will preside.

MAY 14.—

MAY 21.—PROFESSOR C. VERNON BOYS, F.R.S., "Calorimetry." (Trueman Wood Lecture.)

MAY 28.—MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock :—

MARCH 21.—OTTO ROTHFELD, I.C.S., "Progress of Co-operative Banking in India." LORD LAMINGTON, G.C.M.G., G.C.I.E., will preside.

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Monday or Tuesday afternoons, at 4.30 o'clock :—

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

June 16.—C. V. Corless, M.Sc., LL.D., "The Mineral Resources of Canada: The Pre-Cambrian Area."

COBB LECTURES.

Monday evenings, at 8 o'clock :—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MARCH 17 .. British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. H. Bagenal, "Planning for Musical Requirements."

Geographical Society, Lowther Lodge, Kensington Gore, S.W., 5 p.m. Col. H. St. J. L. Winterbotham, "The Choice of a Grid for British Maps."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 7 p.m. (Informal Meeting.) Messrs. L. Gaster and J. S. Dow, "Illuminating Engineering, its Application and Value to the Electrical Industry."

University of London, at King's College, Strand, W.C., 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture VII.)

5.30 p.m. Dr. R. W. Seton-Watson, "A Study of Bohemian History." (Lecture VII.)

At the Institution of Civil Engineers, Great George Street, S.W., 5 p.m. Mr. O. C. A. van Lindth de Jeude, "Practical Hydraulic Engineering Problems in connexion with Navigation." (Lecture IV.)

Birmingham University Chemical Society, Edgbaston, Birmingham, 5.30 p.m. Mr. R. L. Wormell, "Ionisation in Non-Aqueous Solvents."

Rubber Industry, Institution of, Midland Hotel, Manchester, 7.30 p.m. Captain E. E. Buckleton, "Selling Rubber Goods."

East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Sir Alfred Chatterton, "The Utilisation of Underground Water in India."

TUESDAY, MARCH 18 .. Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m. Mr. A. W. Flux, "The Census of Production."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. R. W. Chambers, "Civilisation and Literature of the Anglo-Saxon Period." (Lecture II.)

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. G. W. Johnson, "The Development of the Marine Steam Turbine."

Mineralogical Society, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Prof. F. G. Parsons, "A Comparison of Cranial Contours."

Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, Piccadilly, W., 4.30 p.m. Major G. Home, "Some lesser-known Roman Towns in Tunis and Algeria."

Metals, Institute of (Local Section), Chamber of Commerce, New Street, Birmingham, 7 p.m. Mr. D. Bunting, "Brittle Ranges in the Brasses."

Transport, Institute of, at the Institution of Electrical Engineers, Victoria Embankment, W.C., 5.30 p.m. Mr. E. Falconer, "Relative Efficiency of Horse and Mechanical Power for Road Transport."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. J. C. Dolman, "An Appreciation of the Beautiful."

University of London, at King's College, Strand, W.C., 5.30 p.m. Prof. Hans Driesch, "The Possibility of Metaphysics." (Lecture III.)

Embroiderers' Guild, at the Victoria and Albert Museum, South Kensington, S.W., 3 p.m. Miss Laura Start, "The Weaving and Textile Designs of the Ibans or Sea Dyaks."

Chemical Industry, Society of (Local Section), University Buildings, Bir-

mingham, 7.15 p.m. Mr. A. W. Knapp, "The Fermentation of Cacao."
Hull Chemical and Engineering Society, at the Photographic Society, Grey Street, Park Street, Hull, 7.45 p.m. Dr. W. Thevenaz, "Anthracene and its Derivatives."

WEDNESDAY, MARCH 19 .. London County Council, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Sir Napier Shaw, "Modern Meteorology." (Lecture IV.)
Meteorological Society, 49, Cromwell Road, S.W., 7.30 p.m. Prof. V. H. Blackman, "The Influence of Electricity in the Growth of Plants."
Oriental Studies, School of, at the London Institution, Finsbury Circus, E.C., 5 p.m. Prof. Sir E. Denison Ross, "Old Calcutta."
Transport, Institute of, (Local Section). The University, Manchester, 5.30 p.m. Sir Philip Nash, "Transport Problems."
United Service Institution, Whitehall, S.W., 3 p.m. Captain G. O. Stephenson, "The Submarine Campaign in the Mediterranean subsequent to 1916."
Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Major A. G. Church, "Science in Industry."
University of London, University College, Gower Street, W.C., 6 p.m. Prof. Karl Pearson, "The Current Work of the Biometric and Eugenics Laboratories." (Lecture VI.)
At King's College, Strand, W.C., 5.30 p.m. Prof. Hans Driesch, "The Possibility of Metaphysics." (Lecture IV.)
5.30 p.m. Dr. W. C. Bolland, "The Book of Assizes."
At the Institution of Civil Engineers, Great George Street, S.W., 5 p.m. Mr. O. C. A. van Lidth de Jeude, "Practical Hydraulic Engineering Problems in connexion with Navigation." (Lecture V.)

THURSDAY, MARCH 20 .. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. W. S. Farren, "The Work of the Aeronautical Research Committee's Panel in Scale Effect."
Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. D. S. M. Watson, "Evolution to-day." (Lecture I.)
Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.
Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.
Linnean Society, Burlington House, Piccadilly, W., 5 p.m.
Chemical Society, Burlington House, Piccadilly, W., 8 p.m. (1) Messrs. P. C. Austin and V. A. Carpenter, "Rotatory Dispersion of Derivatives of Tartaric Acid.—Part I. Methylene Derivatives." (2) Messrs. T. M. Lowry and J. O. Cutter, "The Rotatory Dispersive Power of Organic Compounds. —Part XV. The Molecular Weight of Ethyl Tartrate and the Origin of Anomalous Rotatory Dispersion in Tartaric Acid and its Derivatives."
Physical Society, at the Institution of Electrical Engineers, Victoria Embankment, W.C. Jubilee Celebrations. 3 p.m. Reception.
3.45 p.m. (Guthrie Lecture), M. le Duc de Broglie, "Photo Electric Effects in the Case of High Frequency and Allied Phenomena."
6 p.m. Sir Richard Paget, "The Nature and Reproduction of Speech Sounds."
Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.
Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. M. Emile Cammaerts, "Education in England and Belgium Compared."

London County Council, at the Geffrye Museum, Kingsland Road, E., 7.30 p.m. Mr. H. P. Shapland, "Furniture —the Development of the Parlour."
University of London, at King's College, Strand, W.C., 5.30 p.m. Dr. A. R. Pastor, "Spanish Mysticism." (Lecture IV.)
5.30 p.m. Prince D. S. Mirsky, "The History of Russian Literature." (Lecture IX.)
5.30 p.m. Prof. W. C. Buckland, "The Classical Roman Law: Recent Investigations." (Lecture I.)
Structural Engineers, Institution of, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr. H. J. Davey, "The Inspection and Testing of Structural Materials."
Tropical Medicine and Hygiene, Royal Society of, at the Royal Army Medical College, Grosvenor Road, S.W., 8.15 p.m. Laboratory Meeting and Demonstrations illustrating the Etiology and Prevention of Malaria, etc.
China Society, at the School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Miss E. G. Kemp, "Up and Down in Shansi."

FRIDAY, MARCH 21 .. Illuminating Engineering Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. (1) Mr. G. P. Garbett, "The Use of Light for Outdoor Advertisements." (2) Miss M. Partridge, "The Use of Light in Shops, in Show Windows and for Display Purposes."
Royal Institution, Albemarle Street, W., 9 p.m. Prof. Sir F. Keeble, "The Plant Commonwealth and its Government."
Physical Society, at the Institution of Electrical Engineers, Victoria Embankment, W.C., 4 p.m. Jubilee Celebrations continued.
Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. L. Richmond, "My Experiences in Venice."
Medical Officers of Health, Society of, 1, Upper Montague Street, W.C., 5 p.m. Dr. W. A. Daley, "The Organisation of Propaganda in the Interests of Public Health."
Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Presidential Address by Mr. W. H. Patchell.
Engineers, Junior Institution of, 39, Victoria Street, S.W., 7.30 p.m. Mr. P. Parrish, "Sulphuric Acid Plants—New and Old: Constructional Details and Working."
University of London, at King's College, Strand, W.C., 5.30 p.m. Senhor Rangel de Castro, "The Civilisation of Brazil." (Lecture I.)
5.30 p.m. Dr. F. Pavlasek, "Social Conditions in Czecho-Slovakia."
At University College, Gower Street, W.C., 5.30 p.m. Dr. W. Seton, "The Relations between Scotland and England in the Sixteenth Century." (Lecture IV.)
At the Institution of Civil Engineers, Great George Street, S.W., 5 p.m. Mr. O. C. A. van Lidth de Jeude, "Practical Hydraulic Engineering Problems in Connexion with Navigation." (Lecture VI.)

SATURDAY, MARCH 22 .. King Edward's Hospital Fund, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. Allen S. Walker, "Old London and How to See it." (Lecture II.)
London County Council, at the Horniman Museum, Forest Hill, S.E., 3.30 p.m. Mr. H. N. Milligan, "The Natural History of Subterranean Animals."
Royal Institution, Albemarle Street, W., 3 p.m. Prof. Sir E. Rutherford, "Properties of Gases in Vacua." (Lecture IV.)

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All communications for the Society should be addressed to the Secretary, John S

NOTICES.

NEXT WEEK.

MONDAY, MARCH 24th, at 8 p.m. (Cobb Lecture). DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." (Lecture I.)

WEDNESDAY, MARCH 26th, at 8 p.m. (Ordinary Meeting.) Neal Green, "The Fishing Industry and Its By-Products," Professor E. W. Macbride, D.Sc., F.R.S., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 12TH, 1924; Sir HERBERT JACKSON, K.B.E., F.R.S., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Campbell, Andrew, Beckenham, Kent.
Sharp, Mrs. Katharine Dooris, London, Ohio, U.S.A.
Williams, Professor Clement Clarence, Urbana, Illinois, U.S.A.

The following candidates were duly elected Fellows of the Society:—

Bruce, Oswald B., Weston-super-Mare.
Haunz, Charles F., M.Am.Chem.S., Buffalo, New York, U.S.A.
Howgrave, Arthur Atherfold, London.
Porro, Thomas Joseph, Tacoma, Washington, U.S.A.
Shallenberger, Professor Garvin Dennis, Montana, U.S.A,
Vaid, Bakhshi Dina Nath, Rawal Pindi, India.

A lecture on "Personal Recollections of Some Notable Scientific Men" was delivered by Mr. ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of Council.

PROCEEDINGS OF THE SOCIETY.

TWELFTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 27TH, 1924.

SIR ROBERT BLAIR, LL.D.
(Education Officer, London County Council), in the Chair.

THE CHAIRMAN, in introducing the lecturer, said Dr. Myers was now recognised, both in this country and abroad, as the leading psychologist in Great Britain. He was at one time Professor of Psychology at King's College, London; and, later, Lecturer in Experimental Psychology at Cambridge. At Cambridge his initiative and generosity secured the building and equipment of the new Psychological Laboratory; and for some time he was its director.

During the War he became Consulting Psychologist to the British Expeditionary Force, serving as a lieutenant-colonel in the R.A.M.C. The War turned his interest and attention from problems of pure or abstract psychology to its more practical applications, particularly in medicine and industry. On the conclusion of the war, by enlisting the interest and support of eminent men of business and science in the new possibilities of psychological methods, he founded the National Institute of Industrial Psychology, and shortly afterwards gave up his post at Cambridge to become the Director of that Institute. As its Director, and as a member of the Industrial Fatigue Research Board (a Government Department under the Privy Council) he had organised and assisted in many investigations in industrial psychology. Research students and psychological investigators, working under his guidance, had carried out numerous fruitful experiments and enquiries in large firms throughout various parts of the country, and, more recently, in trade and other schools in London and elsewhere. He had of late become especially interested in the possibility of vocational guidance for children leaving schools; and last January obtained from the Carnegie Trustees a grant of £6,000 for carrying out an experimental investigation into the practicability of such a scheme.

The following paper was read:—

THE USE OF VOCATIONAL TESTS IN THE SELECTION OF A VOCATION.

By CHARLES S. MYERS, C.B.E., M.D., Sc.D., F.R.S.,
Director of the National Institute of Industrial Psychology.

By "vocational guidance" is meant the advice given to the worker, based on systematic examination of his mental and bodily condition, as to the occupations for which he is fitted and unfitted. "Vocational selection," on the other hand, is the process of choosing, by such examination, those workers best fitted for the vacancies in

any one occupation. That is to say, vocational guidance aims at finding the best job for the particular worker, whereas in vocational selection we select the best worker for the particular job. Vocational guidance rests on the assumption that of all occupations some are better suited than others to the mentality and physique of any worker; vocational selection assumes that some workers are better fitted than others to any particular job. No one will deny the truth of these assumptions; the only question at issue is the best means of acting upon them.

Until recently, vocational guidance has been left almost wholly to the individual and his family. The young worker, choosing his life's work, may be influenced by his own interests and desires. A love of adventure may prompt him to go to sea; an instinct for self-display to go on the stage; the ambition to rise in the social scale may lead him to take up office instead of artisan work. Or he may be influenced by similar aspirations on the part of his parents, by their desire that he shall follow his parent's occupation, or shall avail himself of the special influence expected of some relation or friend in a particular vocation. The result is too often disastrous. Because a boy or girl has certain interests or desires in relation to a given occupation, it by no means necessarily follows that he will do well at it. The interests or desires may be confined to a very insignificant aspect of his future work. Thus the love of adventure will not make a good seaman; nor will the desire for self-display make a good dancer or actress. So too, a strongly developed instinct of protection and the emotion of tenderness associated therewith will not suffice for success in nursing, medicine or agriculture; and far more than a strongly developed instinct of constructiveness is necessary to make an efficient engineer. Owing to his natural desires and ambitions, the parent's opinion as to the best vocation for his child is notoriously unreliable; he is apt to be singularly blind to the most obvious signs when they point to a career opposed to his own inclinations.

Of late years, school committees have been voluntarily formed for the purpose; the teacher's knowledge of the child has been invoked; and juvenile labour advisory committees have been established. But until quite recently, none of the work has been conducted in a systematic, scientific fashion. The teachers' reports have not proved sufficiently helpful. Nor has vocational guidance, merely based on interview, proved adequate.

The method of interview has until lately been practically the sole basis of vocational selection. A certain number of vacancies occur in a factory. A larger number of employees apply for them. Recommendations from past employers or reports from the candidate's school may be taken into account, but selection and allotment to different occupations within the factory is commonly based on the results of a brief interview. Thereafter, the engaged employee, if found unsuited for his work and undischarged, is wafted from one department to another, on the principle of trial and error, until he finds work at which he proves successful. Let me at the outset emphasize the fact that I do not for one moment suggest the abolition of the interview. It supplies information which, at present at least, can be adequately obtained in no other way. It affords an excellent idea—and by systematic study of the possibilities of the interview, if scientifically conducted, it can doubtless afford even a *more* excellent idea—of the personality of the candidate, his bearing, address and speech, his honesty, loyalty, leadership, etc. But for successful selection we need far more detailed information than this; and this information is only obtainable by special methods of examination, which must be added to the method of interview. These methods involve medical, physiological and psychological examination of the candidate and are already being applied, as we shall see, by some of the more progressive firms. In a rough way, they have already been applied in the case of certain occupations. The soldier is examined for his eyesight, the sailor and the engine driver for his colour vision, a certain standard of physique is required by the army, navy and air force, and of health in certain occupations. But we need to go much further than this. A large number of tests to which I will later allude are now available, by which we can arrive at an estimate of intelligence, memory, attention in its various forms, the strength, speed, precision, dexterity and control of movement, etc. And a large amount of information can be obtained, both from observation of the candidate's behaviour at

the tests, and from questions to the candidate by the examiner, as to other important qualities which are not, at present at least, capable of measurement or submissible to experiment. For this and even more cogent reasons, many of the tests must be applied, or at least their application must be supervised by a properly trained person. The present practice of entrusting colour-blindness tests to examiners untrained in the psychology and physiology of the subject is apt to be at times unsatisfactory. How much more so must it be in testing for other characters far more complex, more intricate and less susceptible of simple, direct measurement. In a very rough way, general intelligence, memory and the like can be determined by the untrained applying standardised tests to groups of subjects, but injustice may be done in individual exceptional cases. Would an engineer place any confidence in the results of a test of brake horse-power carried out by a psychologist or physiologist? How much more unreliable must psychological and physiological tests prove, when carried out by an engineer! Yet this is what educational and industrial authorities are always demanding,—a series of mental and physical tests which can be safely applied without expert supervision, by those untrained in psychology and physiology.

I need hardly lay stress on the immense importance of utilising the best means at our disposal in vocational guidance and vocational selection. What a wastage of time, money and happiness arises from the "round peg" trying to fit the "square hole," and passing by trial and error through a variety of different holes, until at length a hole is found which the peg fits! The employee becomes discontented and dispirited; the employer wastes time and expense in training the employee to work at which he will never do well. If a man is fitted to his work, not only is he happier and more efficient at it, but his health is better, and the sickness records of the factory are immensely improved. Moreover, the enormous wastage at present going on, through workers leaving because they are unfitted for and hence dissatisfied with their job, becomes enormously reduced. It has been truly said that the number of firms in this country who keep a really reliable record of the actual costing of their manufactures is extremely small. Still smaller is the number of those who know the amount of their annual labour turnover and endeavour to estimate satisfactorily and to remedy its various causes,—one of the most potent of which is unsuitability for the job.

The value of systematic vocational guidance at the school-leaving age, and of vocational selection at the factory and office, is fast becoming recognised abroad. In Barcelona, there exists an Institute of Vocational Orientation, supported with an annual grant of about £1,400 from the city and the province, to which boys and girls leaving school are encouraged to apply for a medical, anthropometric, physiological and psychological examination. Students of the Barcelona Municipal Polytechnic are compelled to be examined at the Institute, if they are not making satisfactory progress at their work. In the medico-anthropometric department, measurements are taken of the head, chest, stature, weight, respiratory capacity, visual and auditory acuity; the condition of the digestive, circulatory, excretory systems, etc., is also examined. In the psychometric department tests are applied to determine the intelligence, judgment, memory, attention, imagery, emotionality, speed of reaction, etc., of the subject, and information is sought as to the candidate's interests, ideals, defects, etc. The Institute co-operates with various local Unions or Federations of employees and employers, and has examined into the social and economic condition of about fifty different occupations, including the special physical and mental requirements of each. There are four departments of the Institute, each with a paid qualified expert, and with younger unpaid assistants.

Greater Brussels possesses a rate-supported Inter-communal Bureau for the vocational guidance and apprenticeship of young people. The separate Communes of Brussels are also establishing (three have already been opened) their own Vocational Guidance Bureaux, equipped with the services of medical, psychological and educational experts, who work under the ægis of the Inter-communal Bureau.

In Tokio, a section of the Japanese Association for the Promotion of Industrial Harmony, to which the Government has contributed one-third of its endowment of £800,000, has been established, which is concerned with research in industrial

psychology, the provision of training courses for factory managers, the investigation of factory problems, including those of vocational selection, movement and fatigue-study.

Berlin, of course, has its Institute of Vocational Psychology, now a branch of the Institute of Applied Psychology there, and has devised methods of testing compositors, telegraphists and skilled metal workers.

Geneva has its Institut Rousseau, Paris its Institut Lannelongue, Prague its Academy of Labour, all devoted *inter alia* to the problems of vocational psychology.

In the United States, training in vocational psychology is carried out in most of the Universities, the Carnegie Institute of Technology contains a Division of Co-operative Research, in which is included a Bureau of Personnel Research, financially maintained by a group of industrial and commercial firms who obtain and exchange information relating to the selection, training, organisation and supervision of personnel. Indeed, so numerous are the bodies undertaking research and applying it in regard to vocational psychology, that the United States National Research Council has recently organised a Personnel Research Federation, with the objects of creating a clearing house for information on the subject, of avoiding needless overlap by better co-ordination, and of undertaking hitherto neglected advanced research.

Some form of psychological test is applied to their employees by over thirty firms in the United States. In Germany such tests are used by the Allgemeine Elektricität Gesellschaft, the Siemens and Halske and Osram Companies, the Great Berlin Tramcar Company, the German State Railways, the Post Office, etc. All these concerns have installed psychological laboratories in which vocational tests are conducted.

Germany indeed makes no secret of her aspirations, that by concentrating on the *human* problems of industry and commerce she may attain that success in the present century which she won in the past century by devotion to the *mechanical* aspects of the subject.

Let us now turn to the methods of vocational testing. They are broadly three in number. The first may be called the method of 'sample' tests. These are to be found among the tests contained in the following illustration, devised for shorthand and typewriting for the National Institute of Industrial Psychology by Dr. Cyril Burt. He begins with four tests which form part of a scheme of tests of general intelligence, namely, opposites and synonyms, analogies, mixed sentences, and completions.

I may here note that such tests of general intelligence are proving of the greatest practical value. They were employed in the war by the United States Army, where they were applied to over 1,700,000 soldiers, including about 42,000 commissioned officers, for the selection of non-commissioned and commissioned officers and of men for special duties, for the rejection of the mentally unfit, etc. They are now employed to determine the entrance of students at several American Universities, and in certain examinations in our own Civil Service. They are found to be useful in vocational guidance and selection so as to secure the proper standard of intelligence which experience finds to be requisite for different occupations; too high an intelligence in a given occupation often leading to as great inefficiency as too low an intelligence, owing to the tedium and unrest thereby produced. The National Institute of Industrial Psychology has standardised a series of tests for general intelligence, which are being introduced at their request into several of the more progressive firms in this country. The preparation of a series of performance tests, specially adapted for manual rather than for clerical and literary work, is also well advanced.

In the opposites and synonyms test, a list of pairs of words is presented to the candidate, who is instructed to indicate by a mark against each pair, whether they are opposite in meaning or are identical; in the analogies test, he has to underline a fourth word among those given bearing the same relation to the third as the second bears to the first, *e.g.*, cat; kitten as dog; bitch, puppy, hound; in the mixed sentences test a series of short sentences is given, with the words in each sentence arranged in disorder, of which the candidate has to make sense, stating whether it is true or false; in the completion test, a prose passage is given with various words omitted, which the candidate has to supply. A certain time-limit is fixed for each test, which is insufficient for the most intelligent candidate to complete the whole of it. This intelligence test is followed by a test

of arithmetic and by one of spelling, in which a list of difficult words is given, some of which are misspelt, which the candidate has to correct where he thinks necessary. Then come two linguistic tests (*i*) of synonyms, (*ii*) of definitions. Finally the candidate is submitted to two 'sample' tests, to present which I have made use of this example. Sample tests are so called because they involve work which is a sample of that which the candidate will be subsequently engaged in his occupation. The first of these sample tests is for shorthand. Six passages are read out to the subject at different prescribed rates,—60, 80, 100, 120, and 140 words per minute being successively read to him. Then a series of unusual words of graded difficulty, exemplifying important principles in shorthand, is given to him, which he has to express in proper shorthand outlines and transcribe back into longhand, no time limit being provided. The second series of sample tests is for type-writing. Five tests are employed,—(1) for speed (*a*) with time limit and (*b*) with amount limit, (2) for accuracy, copying a much corrected manuscript, (3) for display, (4) for tabulation of a complicated list of data, (5) for manuscript reading of two very illegible letters. The entire test lasts two hours, and has been found in practice to correlate highly with the opinions of the supervisors of the clerks. That is to say, when the ranking of the subjects according to their success in these tests is compared with their ranking according to the views of their supervisor, there is a very close correspondence. The tests also allow of the preparation of a list of minimal standards which a candidate must obtain, according as (1) he is needed for work of a high order of intelligence, (2) he is required only for routine work, (3) information is desired as to whether after adequate training he is likely to be fit for practical work, or is unfitted for any work whatever in shorthand and typewriting.

The second method of vocational testing involves the employment not of 'sample' tests, but of 'analogous' tests. Thus, in order to examine workers to be engaged on feeding machines, Link devised a gramophone box on the circular horizontal disc of which he placed a larger metal disc, presenting a small sector which was cut out and the size of which could be varied. This open sector when it passed over a certain spot below would allow of a shot dropped to pass through it into a stationary receptacle beneath. When the disc revolved the candidate had to drop the shot at a precise moment so that the ball fell through the slit into the receptacle. Link found that some workers did better with a slow rate of rotation, whereas others did better with a quick rate; and that this corresponded to their varying industrial efficiency with slow or fast-moving machines which they had to feed. The same individual differences in optimum rhythm of movement were noted in our munition factories during the war, some workers succeeding better with fast, than with slower machines, and others vice versa.

The third method of vocational testing attempts to analyse the various qualities required for success in a given occupation and to test each of these qualities separately, instead of employing the complex 'sample' or 'analogous' tests of the two methods previously described. As an illustration of this method, I will describe an examination of 28 telephone exchange girls by Fonteigne of Strasburg. The tests which he finally selected were those for memory of numbers and names, for accuracy of aim, for speed of reaction, for speed and accuracy of cancellation of given letters wherever they occur in a given sheet of printed words, and for speed and accuracy of card-sorting. I omit for the moment the unsatisfactory results of seven subjects. The remainder correlated very highly in order of success at the tests with the order independently ascribed by the telephone supervisor. I present successively the tests-order and the supervisor's order of ranking. Where two girls, say the 9th and 10th are equal in the tests, they are each given an intermediate rank, 9.5.

1	2	3	5	8	9	10	11	12	13
3	2	1	4	5	8	13	7	12	9.5

14	15	19	20	21	22	23	25	26	27
14	11	16	23	19.5	26	21	22	19.5	25

In such an occupation as telephone-exchange work in which breakdowns are frequent from the strain involved, it is obvious that much suffering could be saved by some such carefully devised methods of selection whereby the unsuited are eliminated at the outset of their career. We are able to measure the correspondence between the ranking by tests and the official ranking by means of a formula giving a co-efficient of correlation. This

co-efficient is zero when there is a total absence of correlation; it is +1 when the direct correlation is perfect; and it is —1 when the correlation is inversely perfect, *i.e.*, when the top individual in the one ranking is last in the other, and so on. Between 0 and + or —1 the correlation co-efficient has any value, expressed as a decimal fraction, according to the degree of correlation, direct or inverse. The co-efficient in the above tests for telephone operators was +.698, in Mr. Burt's tests for clerical workers it was +.7.

A few of the telephone operators, as I have said, showed poor correspondence between their ranking according to the tests and according to their supervisor's opinion. Several causes may be responsible for this. The supervisor may have been wrong in his opinion; I shall presently instance a striking illustration of such an error. Or the tests may have been inadequate; there can be no doubt that they are capable of improvement. General intelligence, too, must play some part in telephone exchange work. How important a part remains to be ascertained; but a highly intelligent individual may be able by round-about ways to compensate at her work for deficiency in one or more of the abilities which are determined by these different tests. It will be recalled that some tests, highly correlated with general intelligence, were included in the examination; whereas others, accuracy of aim and speed of reaction, are not correlated with general intelligence. Again, each of the tests is given the same weight in determining the final rank of the operator. But more careful research will certainly discover that some traits are more important for telephone work than others. Consequently instead of determining the final ranking by averaging the ranks in each test, certain tests will need to be "weighted," thus allowing of greater importance being given to them than to others, in the settlement of the final order based on the results of all the tests. Further, the tests need to be supplemented by others, such as the ability to interpret indistinctly heard words. In testing for visual acuity by means of letters, it is found that some subjects are ready to interpret the vague indications suggested by letters really imperfectly seen, whereas others stolidly read only the letters which are clearly visible. So it is with the discrimination of two near points simultaneously applied to the skin. There is a type of person ready to interpret suggested signs, and another type indisposed to do so. Anyone who has ever heard a foreign language through the telephone will realise the importance of the interpretation of indistinctly heard sounds for the most successful telephone exchange work. Moreover, the supervisor may base his opinion of the operators on such factors as obedience, punctuality, patience and courtesy, which the tests fail to take into account, or may be more or less unconsciously prejudiced in favour of or against some particular operator. Indeed, the marvel is that in all these circumstances the co-efficient of correlation should be so high. But we have not yet considered one important factor, which may affect the degree of correspondence in the two ranks,—the factor of interest. One of the seven operators whose ranking differed strikingly in the tests from that of the supervisor, did very well in the tests, but was comparatively low in the supervisor's order of ranking. The latter, when her attention was called to the fact, said, "Well, I am not a bit surprised. The girl could make an excellent telephonist if she only chose."

In its experience in this country, the National Institute of Industrial Psychology has met with similar instances. In one case, the tests devised for the selection of packers gave much better correlation co-efficients when they were correlated with the results of a special speed test of packing applied to the girls, than when they were correlated with the girls' average output as determined by their piece-rate earnings. Nevertheless, this firm estimate that the introduction of vocational tests into its factory has saved it at least £5,000 per annum.

On the other hand, there were one or two cases among the telephone operators, where girls who did poorly at the tests were ranked high by their supervisor. Doubtless this is in part explained by a lack of interest in the tests or a failure to do well under experimental conditions.

In this country, the National Institute of Industrial Psychology has devised a series of tests for dress-making, which are being successfully applied to the selection of apprentices in one of the largest firms in London. Ten tests are applied simultaneously to a group of 24 girls, taking 55 minutes for this application. They

include speed tests in knotting, threading and pricking, tests for good quality of work in the perception of parallel lines, bisecting lines, co-ordinating eye with hand movement, in lightness of touch, and tests of observation and memory.

The present value of the science may be judged by the following illustrations. A selection had to be made among apprentice tool-makers and machinists, of those best fitted for a course of intensive training. The foreman ranked these lads twice, first according to his original estimate of their abilities and later according to a final estimate of them after several weeks of close intimacy during the period of their training. Meanwhile Link applied to the chosen apprentices a series of three tests,—(1) the 'cube' test, in which a large cube had to be built up as quickly as possible from a number of smaller cube-bricks, one or more sides of which were painted in a given colour, so that all four sides of the larger cube were so coloured. (2) The Stenquist test, in which the time was recorded for assembling a series of simple mechanisms, such as a lock, a bell, etc.; a 'form-board' test, in which wooden pieces of different shape had to be fitted as quickly as possible into a board from which gaps of exactly corresponding size had been removed. Now the combined ranking obtained from these tests corresponded very indifferently with the *original* ranking by the foreman, but it corresponded very closely indeed with the *later* ranking by the foreman after he had had several weeks' experience in instructing his apprentices. The correlation between the tests and the foreman's first ranking was only .28, whereas between the tests and his second ranking it reached .9, perfect correlation being, it will be remembered, unity. Here are individual examples of the discrepancy between the foreman's two rankings and of the successful ranking by the tests.—A pleasant willing youth, first ranked by the foreman as fourth, but later as ninth, came out ninth in the tests; an overgrown, 'slip-shod,' dreamy-looking youth, first ranked by the foreman as tenth, but later as fifth, came out 1st, 2nd and 5th in the three tests, respectively; a third apprentice, ranked first as eighth, later as fourth by the foreman, came out fourth in the tests; yet another apprentice, ranked successively as fifth and twelfth by the foreman, came out eleventh in the tests. It may be argued that this particular foreman happened to be exceptionally ignorant, at the start, of the abilities of the apprentices under his charge; but for my own part I suspect that such ignorance is far from uncommon, and I prefer to stress the great help which can clearly be rendered by systematic tests towards selecting the ablest candidates for a given job.

The National Institute of Industrial Psychology has recently devised a series of engineering vocational tests, which has already been applied in a large firm with the object of determining which of 12 branches of the trade each of 250 apprentices is best-fitted or unfitted to pass through. The series includes tests of general intelligence and of spatial judgment (size and shape), motor ability, manipulation and assembly. In the hands of a trained investigator these tests also serve to estimate certain important traits of character, such as impatience, thoroughness, systematic methods of work, etc. Questions bearing on the home and school life and the interests and experience of the apprentice are also asked. Other engineering firms are introducing these tests, realising the saving in time and the gain in efficiency that result from their use.

In his research, for the Industrial Fatigue Research Board, into the qualities and tests required for compositors, Muscio obtained co-efficients of .71 and .80 respectively in the correlation between the ranking by ten tests and by the management in two printing establishments. The tests he employed were—(1) a 'cancellation' test, involving attention, fatigue and speed of action, at which the compositor was engaged for two minutes in cancelling every successive *e* in pages of meaningless French matter submitted to him; (2) a 'substitution' test involving, in addition, memory, in which different numbers had to be pencilled within a series of different geometrical figures according to instructions given at the top of the page submitted to him, *e.g.*, within every circle the number 1 had to be placed, within every triangle the number 2, within every star the number 3, and so on; (3) a 'directions' test of general intelligence, in which the subject had successively to carry out as many different instructions as possible within a given time; (4) a 'match-board' test of dexterity, comprising two tests each

lasting 30″, the board being placed in the first at arm's length, in the second much closer to the body, and the subject having to insert into the holes on the board as many matches as possible within the time given. Owing to difficulties in scoring, Muscio had to omit a valuable form board test, in which wedge-shaped blocks, resembling the 'quoins' used by compositors to fill spaces in the compositors' 'case,' had to be inserted into a board from which spaces of corresponding size and form had been cut. Muscio determined by the method of partial correlation the extent to which these different tests involved the same capacities, calculating the correlations between the tests themselves as well as between each test and the composing efficiency. He was thus able to weight the importance of the various tests and to reach the already-mentioned results, which are indeed remarkable seeing that composing efficiency, *i.e.*, the ranking by the management, depends also on such here untested factors as trade knowledge, honesty, duty, interest, ambition, etc.

We have yet to discover the relative values of the three methods of procedure in vocational testing,—by sample tests, by analogous tests, and by tests for specific abilities determined by analysis of the occupation. In regard to tests for motor abilities we have evidence of very low correlation between them, whereas the tests for general intelligence correlate highly with one another. It is doubtless a useful hypothesis to assume that there are a few general abilities, several group abilities, and many specific abilities; but their nature and their number we have yet to ascertain. It is more certain that in many individuals at school-leaving age, those abilities have not become fully developed or completely stabilised, and that consequently provision for vocational guidance and the examinations devised for this purpose need to be continued after the boy or girl has entered on his career. We also need further knowledge as to the influence which practice at this occupation may have on success at the tests devised to estimate his abilities in that direction. But although vocational psychology is so young a science, it is already capable of yielding information fuller and more precise than can be reached by the older unsystematic methods of procedure. Further progress in vocational psychology is only possible by experience, as in surgery or medicine. Just as the surgery of to-day is far in advance of that of 200 years ago, and is far behind that of 200 years hence, and just as that advance has only been possible by experience, so vocational guidance and selection must depend for their future on the encouragement and opportunities offered for putting their principles into actual practice.

DISCUSSION.

The Chairman, in opening the discussion, said Dr. Myers had introduced the audience to a very vast subject in a very interesting way. It was something like 40 years after the teachers had gone into the schools in a public way that the doctors went there. He did not think it would be another 40 years before the psychologist went after the doctor into the schools. Just as every child now underwent a medical inspection in the school, so in the future, probably at the end of his school career, every child would have to submit to an examination by a psychologist. There would be a good deal of trouble in England before that became compulsory, because while Earl Grey had got on the country's nerves occasionally, by depicting the terrors of the next war, those who had followed the tests and the diagrams of the author that evening must have begun to think of the horrors of industrial peace. For his own part he was perfectly happy in having finished his career before he had had to undergo tests of that kind!

It was interesting to think what the science might lead to, when experience was sufficient, compared with the present practice. The practice had been modified in recent years, but speaking generally, it still consisted very largely of throwing every year out of the elementary schools half a million of children on to the markets. These children had to fit themselves in to whatever posts were available. What it would be desirable to see some day was a high correlation between the posts which were available and the children who were fitting themselves into them.

His own interest in the question was due to the fact that it was one section of the problem of what, to him, was the most interesting question of the present day, namely, that of the adolescent. The paper put forward one phase of dealing with the adolescent—giving him expert advice as to the kind of employment for which he was best fitted. It would be found, of course, that just as men hitherto had defied Nature which had dealt unkindly with them, and had overcome all the physical handicaps which Nature had given them, so in the future men would be found who would defy the psychologist, and who, years after they had been rejected by the psychologist for a given post, would become Prime Minister or head of a great line of steamships, despite the fact that they had been turned down by the psychologist at a given stage because they had not

a certain class of ability. There would be those exceptional cases, but he thought there was now clear evidence that the author and his colleagues had got on a line which would become common practice before very many years were over.

Experience up to the present had carried the investigators in the subject only a certain distance. There might be more than just the ignorance of that foreman to which the author had referred. The failing of that foreman might have been due to the fact that there were certain people who could become more expert at a job after a little experience than others who were successful at the beginning, on account of the fact that they had character. They had such a character that they would succeed in anything, and it was possible that the foreman in question had not realised that at first, but had seen it afterwards when he had had five or six weeks' experience of his particular apprentices. There were also certain racial characteristics which had to be taken into account. There was the quick wit and nimbleness of the Irish boy. He had seen the Irish boy at work, and had compared him with the slow but long movement of the Aberdeen boy, out of whom at 14 years of age it was extremely difficult to get anything, but who had the stuff in him all the same, and who would show it later on in life. Things like that could not be measured perhaps in the early stages.

It was very difficult for those who were not engaged in applying the tests and working on them day after day to offer any criticism. One could only talk in the most general way about such a new science, and discuss with some of the investigators particular tests; but the author had said one thing which no doubt would be very pleasing to some adults, namely, that too high an intelligence often led to as much unhappiness as too low an intelligence. Those who prided themselves on their intelligence might be gratified to reflect that if they were unhappy in their job this might be due to their having too high an intelligence!

In London for a long time past there had been in the schools what was called a conference; that was to say, a month or so before a child left school the teacher brought to that conference the child's school record. The parent was there to say what he wanted and what he knew about the child, and other persons were there to give advice. There had not yet been brought into that little group the psychologist, but he would come in some day, and then it would be known much better for what the child was fitted.

The author remarked that "Just as the surgery of to-day is far in advance of 200 years ago, and is far behind that of 200 years hence, so with regard to psychology." That was true, but he hoped the psychologist would not forget that in the process of getting their experience the surgeons had killed a great many people!

Mr. C. G. Watkins said he had come from a truly rural part, *viz.*, Buckinghamshire, to learn something, and he had not been disappointed. How the science was to be applied in rural areas he did not know, but he hoped they would in time follow the good example of London and have their own psychologists.

Mr. Leon Gaster asked whether the tests were applied under ideal conditions or ordinary working conditions, and also what was the best age at which to apply the tests. He had come across cases of children who had not shown of their best up to a certain age, and who up to about 14 or 15 years of age had hated their lessons. Yet those children in after life had turned out to be quite successful.

Mr. Morley Dainow remarked that he highly appreciated Dr. Myers' paper, but as the title of it was "The Use of Vocational Tests in the Selection of a Vocation," he would like to be permitted to describe some other work which was being done in this country. He noticed there was a tendency on the part both of the Assistant Director of the National Institute and of the Director himself to refer only to work that was being done on the subject by the National Institute; but work on the subject had been done, and was being done, in this country on a very important scale by independent psychologists. In 1920 he himself as a psychologist had devoted himself to certain occupations which were beyond the scope of the present paper, for instance, the occupation of salesmanship. He had devised a scheme for Selfridge and Company, which consisted of a series of tests, some not unlike the tests which the author had described, and others, new ones, and only the other day he had received a letter from the Departmental Head of Selfridge and Company to the effect that, in regard to 50 juniors who had been examined by psychological tests, when they compared the records of anticipation by psychological examination with the records of achievement behind the counter, in the office, or in the workshop, they found a marked similarity between the anticipation of the psychologist and the subsequent achievement of the examinees.

In *The Times* of yesterday the following advertisement had appeared: "Exceptionally able man, 35-40, required immediately, experienced in textiles retail distribution, possessing judgment and organising ability; salary up to £2,000. Selection based on psychological tests." That was the first occasion on which any great employer of labour in this country had come to a psychologist in order to be able to find a man who possessed real leadership. Dr. Myers' paper might be described as vocational selection for the workers, for the masses; but there was needed, even more importantly, vocational selection for the leaders, for the classes. Most of the tests which the author had submitted had been tests much more of the mental than of any other side; but there were at least three other sides besides mental, namely, disposition, character and personality. Again, most of the tests put forward by the author that night had been tests for technical work, but there were at least

three other kinds of work, namely, administrative, professional and commercial. He suggested, therefore, that the Director of the National Institute of Industrial Psychology should pay some attention to the work which was being done by other psychologists, to the work which was being recognised by heads of commercial and industrial concerns, and to the work which was being applied practically, and which was not merely in the theoretical stage.

MR. T. Ll. HUMBERSTONE said that he was glad the author had referred to the value of the interview pure and simple as a test for efficiency. At the present time the boy candidates for the navy were being selected almost entirely by interview, and he had always argued that that was a defective method. During the war he had been concerned with the selection of candidates for commissions in the army, and he had noticed one thing which many people who were concerned in the same work had noticed also, viz., that some of those selected who did not appear to show evidence of those high qualities of leadership and personality which were so essential for officers of the Army, often showed marvellous and extraordinary bravery and attained high distinction in the war.

One difficulty he saw with regard to the subject matter of the paper was that selection was made at a point of time, and one could not tell what the efficiency would be in ten or twenty years' time.

Another point was whether there was any possibility of forestalling the "crammer." If psychological tests were to be employed as a method of selection, boys and girls would be crammed for them just as they were crammed for examinations.

A further point was that the tests gave the state of efficiency under normal conditions, but not the efficiency in an emergency. One wanted the man who would pull the right lever when the catastrophe was on him, and not merely the man who would pull the right lever when there was plenty of time to think about it.

In all psychological tests it seemed to him the margin of error should be recognised. It ought to be admitted frankly that it was impossible to pick the most efficient. One might pick two, three or four individuals and say that probably the most efficient of the larger group was among those three or four. Perfect selection could not be obtained by any such methods as psychological tests or examination tests.

MR. P. ABBOTT said it had been his lot to apply a great many psychological tests, and the one feature in which he thought that at present they failed was that they did not bring out sufficiently strongly those traits of character which were so very important in after life. He had applied the intelligence tests on boys in various ways, and had made selections in consequence of them, but afterwards he had been disappointed in a great many cases, because there was not present in those boys the character necessary to give full effect to the intelligence which had been evidenced in the tests. The author had provided one method of getting over that difficulty, namely, by the interview, but he had added that the interview, if it was to be successful, should be conducted upon scientific lines. Personally he suggested, however, that the ordinary individual at the present time did not know how to conduct an interview scientifically. No doubt the author would answer, "Bring in a psychologist to the interview," but that could not be done on all occasions, and one had to rely upon oneself in many instances to take the part of the interviewer. He therefore suggested that the psychologist should state how an interview should be scientifically carried out.

MR. R. À-ABABRELTON said that there had been for 50 years a class of people who professed to be able to state what an individual was most fitted for, namely, the phrenologists. After all, boys and girls' heads were things more fixed than those things which had been subjected to the author's tests, and the author himself had admitted that there were many cases where the actual results had not borne out the tests.

MR. ROBERT STELLING said the subject was of real importance at the present time when we were doing all we could in this country to revive industry and commerce, which was in so deplorable a condition. One thing he felt nervous about in dealing with the question of vocational selection and vocational guidance (although he yielded to no one in his appreciation of its importance as a phase of the science of management) was the premature introduction of vocational selection to specific trades. There was an enormous waste through boys drifting in to the wrong class of occupation, but the trade unions were saying, "Are you going to use these tests to keep people out of our industry? If you are we are going to have nothing to do with it." The answer was, "No; we are trying to fit people to the trades." But he was afraid there was a long way to go yet before the trade unions could be convinced that that was the purpose of the tests.

Another important point was that the conditions in our industries to-day were not standardised. The methods certainly were not standardised, and particularly he would refer to the working conditions. He had in mind the case of a skilled turner who worked for many years under a gallery, and whose only source of illumination was a small gas jet. The man had been working on a second-hand lathe for seven years. The works were then suddenly moved into a large modern shop with perfect lighting, and the man was put on to a lathe right out in the open. The result was that he could not work under those conditions, and went back again to a little shop in a back street, where the conditions were more like what he had always been used to. That showed the necessity for standardising methods and for standardising working conditions. He ventured to suggest that if much was going to be done in the way of

useful advice to the youth about to enter upon his life's work in a trade, the conditions of that trade must first of all be studied and analysed and be brought as near perfection and simplicity as possible. Recently a firm in the north of England had been making very elaborate changes and investigations into certain of their methods. As a result of those changes they had been able, with greater comfort to the workers, to increase the output of the department by something like 55 per cent. The extraordinary thing, from the point of view of the matter which was being discussed that night, was that, whereas the skilled workers did not make so tremendous a headway, their wages only going up in fact from 40/- to 45/-, the principal increase of output was among the lesser skilled workers, who had been earning only 30/- or 32/-, and the average wage had gone up in that department from 34/- to 42/- during that period. That seemed to show that if the methods were standardised the work was made open to a far greater number of people, and far more people were able to enjoy the work, to do good work, and to earn good money. He suggested, therefore, that the National Institute should take every opportunity possible for collaborating with industrialists, and particularly that new branch of industry, the industrial engineer, in order to ascertain what were the best ways in which the job could be standardised and analysed, so that they could combine to find the happiest and most suitable work for our youth entering industry to-day.

Mr. G. Harrison said Great Britain was an industrial country. Many thought that it was very much over-industrialised. Consequently the great bulk of the children leaving the elementary schools were fated to take part in monotonous industrial work, whether they liked it or not, and whether they were fitted for it or not. He desired to ask the author whether he had found in the course of his tests that there was any proportion of human beings worth speaking of who were really fitted to pursue, for the course of their lives, a monotonous task of that kind. It had been suggested that the author had not laid any particular stress upon character, and that his tests were merely intelligence tests. He would like to submit, that even from the point of view of an intelligence test, a test of the capacity of a child or a man to go through a monotonous task was not really an intelligence test, and that if it was found that there was a sort of rebellion or resentment against pursuing such a thing, that would be an indication not of a bad character, but of an exceptionally good one. What the psychologist was after in his tests was to try to make human beings fit into a particular system, and personally he doubted very much whether the psychologist would be able to do it.

Miss S. D. Lowe asked what was the best stage of adolescence at which to apply the tests. She happened to be closely connected with juvenile employment, and found that a tremendous development or deterioration of character, as the case might be, among adolescents occurred during the time just after they left school, and were freed from the discipline of school life. Character developed or deteriorated rapidly between the ages of 14 and 15. Therefore, would the author state whether the test should be applied just before the children left school, when they were still under discipline, or should it be applied after they had left school, say, at the age of 15, or should it be applied at both periods in order to form a correct opinion?

Mr. J. F. Butterworth thought the time was not far distant when there would be established in this country, in all the big cities, departments which would be able to furnish psychologists and physiologists to test children for their fitness for work, just as at the present time doctors tested them for their health. The question of psychology undoubtedly was one of the most important features in industry to-day, and he was sorry to say that up to the present time this country had perhaps been the most backward of the big countries in taking it up. Many years ago he had had a friend who had been a psychologist without knowing it. His friend had employed at various times in America over ten thousand workers, and in a country such as America, the most polyglot nation in the world, he very quickly found that if he put his men together in huge gangs, he got merely average results, but that when he divided them up into gangs of Irishmen, Scotsmen, Hungarians, Italians, Germans and Englishmen, he was very easily able to set up a fierce competition between the gangs. His friend used to put up a score board saying what the output of each gang was, and directly the excitable Irishmen saw their figure was being exceeded by another gang, they went to work to beat it. The result was that his friend obtained results which were absolutely marvellous: he had undoubtedly applied his psychology in a practical manner. His friend had also very quickly found that when he had been commissioned to build a Wesleyan Chapel, he did not get the best results from Roman Catholic workmen, or that if he had to build a saloon, he did not get the best results from teetotalers. That was a practical application of psychology.

The Author, in reply, said it was not the psychologist's object, as a result of vocational guidance, to force anyone to go into a particular occupation. The psychologist here merely advised. The ideal of vocational guidance was to get the subject to believe that it was his own decision. That could be done by successful advisers, and in that way the best results were obtained.

Mr. Gaster and Miss Lowe had both asked the very difficult question, namely, at what age the tests should be applied. It had to be remembered that the tests were being used as a supplement to the interview, so that it was extremely difficult to answer the question. There had been too much supposition that night that in the tests there was

something absolutely new—a revolutionary thing which was going to alter the whole course of the child's existence. What he desired the audience to bear in mind was that he was urging the tests as something supplementary to the interview. The interview must always be there, so that the question as to when the tests should be applied was like asking, when should the child be advised as to what he should go in for? That must depend on a vast number of things.

With regard to Mr. Gaster's question as to whether the tests were applied under ideal conditions or working conditions, that varied a very great deal.

Mr. Dainow had alluded to the question of salesmanship. He was glad to hear that Mr. Dainow had been so successful. He only wished he had known about it at the time when he had been preparing the paper. All he had made use of was, so far as possible, the data in this country and abroad which had appeared in print.

He had been interested in Mr. Humberstone's remarks, first with regard to cramming. That had always been urged against the intelligence tests, but it did not in practice appear to be a very important objection. He himself had gone through the intelligence tests some little time ago, after having had a general knowledge of their nature, and he had been almost as flustered as he would have been if he had never known anything about them.

Mr. Abbott had said that the tests did not bring out character enough. They were not devised for that purpose; as he had stated before, they were merely a supplement to the interview. If the help of the psychologist was asked so that the interview could be conducted in a more scientific manner, he felt that a great deal could be done in that direction.

Mr. Stelling had stated that the trade unions were likely to be against vocational guidance and selection. Personally he had had a good many talks with trade unionists and all sorts of workers, and he had found that the problem of vocational psychology was one in which they were most interested. He had never received any unfavourable comment about it from that class of people. Its object was to get the best people in those jobs for which they were best suited, and to save them from having a wrong job. In Berlin he had been informed that the Engineers' Union had gone so far as to support the Charlottenburg Laboratory financially, in order that they might not have "duds" getting into their Union. He could assure Mr. Stelling that, so far as his experience went, there was not likely to be any opposition from the trade unions.

With regard to another speaker's remarks, the Institute had also found that, with the improvement of conditions, it was the least expert workers who were most affected. It took a very great deal to improve a really expert person a little more.

Mr. Harrison had asked a very interesting question with regard to the fitness of people for monotonous tasks. There was a good deal of work going on now in that particular subject, some of which had been published in the Institute's *Journal*, and some of which had been carried out partly by the Fatigue Research Board.

Votes of thanks to the Author and Chairman concluded the meeting.

OBITUARY.

PAUL GREGORY MELITUS, C.S.I., C.I.E.—Mr. Melitus, who, as a member of the Indian Civil Service, had a long and successful career in Bengal and Assam, died on February 23rd. Born in 1858, he was educated at Marlborough and Balliol College, Oxford. Having passed the I.C.S. competitive examination he went to India in 1880, and became an Assistant Magistrate and Collector in Bengal. From 1886 to 1891 he filled respectively the offices of Assistant and Deputy Commissioner, Assistant Secretary to the Chief Commissioner of Assam, and acting Postmaster-General of Bengal. He was then appointed Under-Secretary Home Department, Government of India. Subsequently he was Secretary to the Chief Commissioner of Assam, and later Judge and Commissioner Assam Valley Districts. In 1905 he was chosen for a seat on the Board of Revenue, Eastern Bengal and Assam, afterwards becoming its First Member. His last post in India was that of Commissioner in Bengal, and he retired in 1913. He was made a Companion of the Order of the Indian Empire in 1894, and a Companion of the Star of India in 1912. He had been a Fellow of the Royal Society of Arts since 1906.

CORRESPONDENCE.

THE TREATMENT OF THE DEATH-WATCH BEETLE.

I regret I was unable to attend the reading of this paper by Professor H. Maxwell-Lefroy, to make the following suggestion.

The beetle breathes and, therefore, can be, as I have verified by experiment, exterminated by periodical "gas attacks." The labour and cost of this is nothing like so heavy as the inefficient use, when practicable, of fluids.

A. E. PARNACOTT,
M.I.A.E.

RECENT DEVELOPMENTS IN NAVAL ARCHITECTURE.

SIR EUSTACE W. H. TENNYSON-D'EYNCOURT, Director of Naval Construction and Chief Technical Adviser to the Admiralty, recently delivered the Watt anniversary lecture before the Greenock Philosophical Society, upon this subject.

The developments in naval architecture down to

the present time, he said, could only be appreciated properly if one considered for a moment the conditions under which ships were designed and constructed before the days of James Watt and the steam engine. British warships were standardized by the Admiralty in their principal dimensions, and consequently could not be departed from. All the useful knowledge was kept secret; and as a result there had been little real progress in the science of naval architecture since the days of Queen Elizabeth. The opening of the first English school of naval architecture at Portsmouth in 1811 was the first real step taken whereby the study of the science was inaugurated and encouraged. Referring to the introduction and utilization of the mine, the torpedo, the aeroplane, the use of wireless telegraphy, and all other adjuncts which have been developed, the naval advances of the nineteenth century had yet to be determined by actual warfare, and the Great War was the acid test of all the modifications in naval design.

The aeroplane must play an enormously important *rôle* in any future war; the mine was used with effectiveness by both sides in the recent war; the torpedo was made the most dreaded weapon on that occasion; and the development and use of the submarine was one of the most unexpected features, and necessitated the design and construction of vessels for the purpose of hunting and destroying this new form of torpedo craft, and developing devices for detecting the presence of the submarines and to accomplish their destruction. In naval architecture itself there had been striking improvements in the designs of ships and their propulsive qualities; and research work had enabled the naval architect to take full advantage of the improvements in materials which had been offered him by the metallurgist and the steel-makers. At the present time, armour capable of withstanding the attack of modern shells could be produced of half the thickness and weight which was required 40 years ago to resist the much inferior attack of that date. Within the last year or two marked improvements had been made in the qualities of structural steel; and recent processes would enable appreciable reductions to be made in the weight of the structure of new ships. The improvement which had taken place in the various types of engines had been steadily maintained by the introduction of the steam turbine, the utility and economy of which had been further developed by the introduction of gearing which had had marked results in improving the propulsive co-efficient of vessels.

Concurrently with an improvement in the engines there had been introduced more economical methods of raising steam, and fuel economy had been improved by the various developments in machinery and boilers, and assisted by the use of the geared turbine. A striking advance in this direction had resulted from the introduction of the internal combustion engine, but it had been found so far impracticable to introduce this type into warships for propelling purposes. These engines were installed for driving dynamos, with the consequent advantage that steam need not be raised when in harbour. The introduction of oil fuel for steam raising had had a most marked effect on the design and construction of ships during the last ten years. Its adoption contributed in no small degree to the successful operation of the Fleet during the war. Without its use we could not have approached the power required for the high speeds of our torpedo boat destroyers and light cruisers. Our warships had demanded larger complements, both of officers and men, by the introduction of these and other appliances, especially wireless telegraphy. There was a great increase in the number of vessels constructed for the Navy during the war, the tonnage being 2,000,000.

The effect of the war upon designs had been great, and had brought about striking developments. The ever-increasing size was, of course, remarkable, and the steady increase of the use of internal combustion engines was a great feature of recent developments. That this would continue there was not the least doubt. In concluding, the speaker said that the present position as regarded the provision of facilities for obtaining the highest training for naval architects and marine engineers might generally be regarded as very satisfactory, and the continued development of naval architecture was thereby assured.

PIG BREEDING IN SCOTLAND IN 1923.

There has been continuous progress in pig breeding in Scotland during the year 1923, notwithstanding the fact that there have been many disappointments for the pig-breeder. It is satisfactory, however, to be able to put on record that the pig population in Scotland as at June 4, 1923, showed an increase of 35,143, or 23.29 per cent. over the previous year. The total population of pigs at that time was 186,027. This figure, although a satisfactory one from the point of view of Scotland, compares very badly with the figures as applied to other parts of the world, the total pig population of Great Britain being 2½ millions, and if the whole of Ireland is included, 3½ millions, out of a total pig population in Europe of some 55 millions.

The increase in the pig population of Scotland is highly satisfactory, as it would seem to indicate that the business of swine husbandry has now become an essential part of agriculture; and, indeed, this fact is brought out from an examination of the details giving the numbers of pigs bred in each Scottish county. The figures show, amongst other things, that the ancient prejudice against pig breeding in the Scottish Highlands has disappeared. There was a time when one of the names which the Gaelic-speaking population of Scotland gave to the devil was "The Big Black Pig;" but at present there are something like 100 herds of large black pigs in Scotland, pretty evenly distributed all over the country, and some of the more notable of these are situated in the Western Highlands.

Unfortunately, the number of breeds of pigs which are recognised in Great Britain as pure breeds is still increasing, and it looks as if the number would increase to fifteen pure breeds in all. This multiplying of the breeds is not regarded favourably by the bacon curer, as it in nowise contributes to the production of the bacon pig, which, after all, is the natural corollary of pig breeding. The cross-bred pig, it would seem, is preferred by the bacon curers before the pure-bred animal. But it is quite a mistake to suppose that a cross-bred pig is any better than a bacon pig derived from a pure breed. It is altogether a question of selection and feeding.

The Scottish pig breeders have pretty generally come to the conclusion that the cross-bred pig seems to mature earlier, and undoubtedly commands a readier sale for bacon purposes than the pure-bred animal. In corroboration of this view, it may be mentioned that, at the last Smithfield Show in London, the championship for the pig best suited for the manufacture of bacon was awarded to a cross between a large white boar and a large black sow. At the age of 5 months and 3 weeks this particular animal scaled 2 cwt. 5lb., live weight, without being in the least degree too fat for bacon curing purposes.

A good many Scottish breeders are at present trying to cross with the large black sire and the large white sow. Others, again, are trying the large black sire on the middle white sow. The results in either cases have been quite satisfactory, as have many other crosses in which the large black sire is being used.

The sire is undoubtedly pre-potent in the breeding of pigs, and, for that reason, it is always desirable to have a pure-bred sire where cross-bred pigs are produced. Experiments have shown that the use of a pure-bred boar has, by comparison, shown an increase in pig production of 40 per cent. over the common nondescript boar. This, then, must be one of the principal objects of the pedigree pig breeder—namely, to supply pure-bred sires of whatever breed may be particularly fancied.

Pig breeders in Scotland have had some serious misfortunes during 1923. First of all came the foot-and-mouth disease, which has practically stopped all movement of swine throughout the country; and the great exhibition of pigs which was to have taken place at Glasgow Dairy Show was prohibited. Similarly, and for the same reason, the Edinburgh Fat Stock Show did not take place, and the entry there would have been a record. Then, during the latter part of last year, there was continuous rain; and, latterly, extremely cold and wintry weather, so that the outdoor system of raising pigs has to be carried on under the most trying weather conditions. Farrowing in winter in Scotland, at all times, is a risky business; but, during the later months of the year it was necessary to provide heat in the farrowing styes, as otherwise the piglets would have received a setback from which they would be unlikely to recover.

LOUDON M. DOUGLAS.

COTTON AND RUBBER IN PERU.

The principal products of Peru, writes the British Vice-Consul at Callao, are cotton, sugar, wool, hides and skins, rubber, rice and coca.

Cotton.—The total production of cotton in Peru in 1921 was 40,769 metric tons and in 1922 probably more than 42,000. The year 1923 may show an increased production of perhaps 10 per cent. over the preceding year. The production of Tangüis (named after the discoverer of this highly successful blend of rough and smooth cotton) reached about 40 per cent. of the total, and as a good price was obtained, it has led to a more extended sowing of this class of cotton. Its woolly nature lends itself to admixture with wool in the manufacture of woollen goods. Last year over 90 per cent. of the Tangüis went to Liverpool. Of the export of 39,952 metric tons (gross) in 1922, England took over 34,000 tons and the United States nearly 5,000 tons. In the first half of 1923, 8,890 tons were exported, against 13,601 tons in the same period of 1922.

In the regions of the upper reaches of the Amazon, the crop in 1922, although a disappointing one owing to the destruction done in the cotton-growing areas between the Huallaga and Ucayali rivers during the revolution in 1921, showed an increased return on the previous year. In 1922 the exports from this region amounted to 1030 metric tons, all rough and semi-rough qualities. Much larger areas were put under cotton in 1923.

Rubber.—Wild rubber abounds in the Amazon regions, its original home, and whence the Far Eastern product was transplanted. The export, which had been only 137 tons in 1921 (the official figure, which probably did not include December), increased to 602 tons net in 1922. An examination of the possibilities of creating in the Amazon district an independent source of supply of plantation rubber for American consumption is about to be made by an American Commission. The sum of half a million dollars has been voted in the U.S.A. for investigation in the Philippines and Central and South American States, and the latter are vying with each other in offering inducements. The restriction on production—under the Stevenson arrangement—of Eastern rubber has led the United States, which require over 70 per cent. of the world's output, to contemplate a time when the supply from the present sources may not be sufficient to meet their needs. There are, it is stated, many millions of trees in the Peruvian rubber forests, but the wild rubber cannot be collected profitably, and the trees would be cleared for the proposed plantation. As it would require some seven years before any rubber could be produced from the latter, it is thought that the proposed railway from the Marañon to the Pacific might be available. In this case the product from the eastern side of the Andes could be landed in New York *via* the Pacific coast and Panama Canal in a fortnight. The alternative—and present—means of transport is *via* the Amazon rivers for nearly three thousand miles to the Atlantic. The Peruvian Government, eager to attract a new industry,

offers the Commission very large tracts of land free, together with many other advantages, such as duty free imports of materials, etc. It is considered that the lack of a supply of labour in these regions, necessitating contracting labour from abroad, will militate against the success of this scheme.

GENERAL NOTE.

SUMATRA RUBBER.—Attention has been called in *Tropical Agriculture* to the amount of native-owned rubber in Sumatra—an island which is more than twice the size of British Malaya, to the south-west of which, in the Indian Ocean it is closely situated. It is estimated that the natives own some 50 million trees, which, under good management, should yield 80,000 tons of rubber per annum—an amount quite capable of influencing the world's market price. This might be important at times when attempts are made to raise the price of rubber by restriction of Company operations. Influence of this kind was actually experienced in the initial stages of restriction in the Federated Malay States in 1920. It is, therefore, important that statistical data should be obtained and studied in respect of native cultivations. Regarding the quality of Sumatra native rubber it would appear that for the most part it is equal to off-quality smoked sheet.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock :—

MARCH 26.—NEAL GREEN, "The Fishing Industry and its By-Products." PROFESSOR E. W. MACBRIDE, D.Sc., F.R.S., will preside.

APRIL 2.—SIR LYNDEN MACASSEY, K.B.E., "London Traffic." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

APRIL 9.—FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum." PROFESSOR C. VERNON BOYS, F.R.S., will preside.

APRIL 30.—BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "The London Dock District and its Roads."

MAY 5 (Monday).—T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MAY 7.—J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation." ADMIRAL OF THE FLEET SIR HENRY JACKSON, G.C.B., K.C.V.O., F.R.S., will preside.

MAY 14.—

MAY 21.—PROFESSOR C. VERNON BOYS, F.R.S., "Calorimetry." (Trueman Wood Lecture.)

MAY 28.—MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock :—

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

Monday or Tuesday afternoons, at 4.30 o'clock :—

MAY 27.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

June 16.—C. V. Corless, M.Sc., LL.D., "The Mineral Resources of Canada: The Pre-Cambrian Area."

COBB LECTURES.

Monday evenings, at 8 o'clock :—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

SYLLABUS.

LECTURE I: MARCH 24.—Colloids. Suspensoids and emulsoids. Gelatin as an emulsoid and amphoteric colloid. Isoelectric point and properties of isoelectric gelatin. Combination of gelatin with silver nitrate and other salts.

Effect of gelatin on reactions involved in making a photographic emulsion. Ripening of silver halides; effect of various reagents. Physical processes involved in development. Development in hot climates and prevention of swelling. Reticulation.

LECTURE II: MARCH 31.—Hardening of gelatin. Ordinary fixing and acid fixing baths.

Medium free silver halide. Gelatine as a retarder of development. Black and grey silver images. Coloured silver images and silver colour scale. Production of coloured images Gelatine as a sensitiser.

LECTURE III: APRIL 1.—Photohalides and the visible image. Sensitising action of silver ions. Latent image. Duplication of light action by chemical agents. Silver halide grain as the unit. Sensitive centres on the grains. Nucleus exposure. Nature of the sensitive centres.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MARCH 24 ... Geographical Society, 135, New Bond Street, W., 8.30 p.m. Dr. L. Koch, "Northward of Greenland."

Mechanical Engineers, Institution of, Storey's Gate, S.W., 7 p.m. (Graduates' Section). Informal Discussion on "Failure in Metals."

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Mr. W. E. Leslie, "Telepathy."

Architectural Association, 34, Bedford-square, W.C., 7.30 p.m. Miss M. Jourdain, "The Architect as Designer of Furniture."

University of London, at King's College, Strand, W.C., 5.30 p.m. Dr. R. W. Seton-Watson, "A Survey of Bohemian History." (Lecture VIII.)

5.30 p.m. Senhor Rangal de Castro, "The Civilisation of Brazil." (Lecture II.)

TUESDAY, MARCH 25 ... Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John-street, Adelphi, W.C., 6.30 p.m. Mr. H. S. Rowell, "The Balancing of Automobile Engines."

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. J. Ward, "Some Notes on the Theory of Lubrication with particular application to the Mitchell Thrust."

Colonial Institute, Hotel Victoria, Northumberland-avenue, W.C., 4 p.m. Rt. Rev. Bishop G. Jones, "The Nile Route to Uganda."

Photographic Society, 35, Russell-square, W.C., 7 p.m. Mr. J. D. Johnston, "Developments of Pictorial Photography in England and America."

Royal Institution, Albemarle-street, W., 5.15 p.m. Prof. G. Gordon, "Ballads." (Lecture I.)

University of London, at King's College, Strand, W.C., 5.30 p.m. Prof. Smal-Stotsky, "Shevchenko and Modern Ukrainian Literature."

WEDNESDAY, MARCH 26 ... London County Council, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 6 p.m. Sir Napier Shaw, "Modern Meteorology." (Lecture IV.)

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5 p.m.

British Academy, at the Royal Society, Burlington House, Piccadilly, W., 5 p.m. Dr. T. Borenius, "English Primitives."

Oriental Studies, School of, London Institution, Finsbury Circus, E.C., 5 p.m. Miss E. D. Edwards, "Manchuria."

United Service Institution, Whitehall, S.W., 3 p.m. Rear-Admiral H. L. Mawbey, "The Past and Future of the Royal Indian Marine."

Glass-Painters, British Society of, at the Art Workers' Guild, 6, Queen Square, W.C., 5.30 p.m. Dr. T. M. Legge, "Specimens of 15th Century Stained Glass"; Mr. F. S. Eden, "Ancient Stained Glass in London."

University of London, University College, Gower-street, W.C., 5 p.m. Prof. K. Pearson, "The Current Work of the Biometric and Eugenics Laboratories." (Lecture VII.)

5.30 p.m. Dr. W. Seton, "The relations between Scotland and England in the Sixteenth Century." (Lecture V.)

At the Royal College of Music, Prince Consort Road, S.W., 5 p.m. Sir Henry Hadow, "English Composers of the Tudor Period." (Lecture II.)

Microscopical Society, 20, Hanover Square, W., 8 p.m. 1, Mr. G. O. Searle, "Methods of Mass Production in Sectioning Flax Stems." 2, Dr. H. Wrighton, "Microscopical Metallurgy." 3, Demonstration of "Technical Microscopy." 4, Mr. J. E. Barnard, "The Setting up and Adjustment of a Microscope."

Japan Society, 22, Russell Square, W.C. Mr. Hugh Byas, "The Press in Japan To-Day."

THURSDAY, MARCH 27 ... Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Lieut.-Colonel H. E. O'Brien, "The Future of Main Line Electrification of British Railways."

Industrial League and Council, Caxton Hall, Westminster, S.W., 7.30 p.m. Sir George Paish, "Trade Depression and its Remedy."

Auctioneers and Estate Agents Institute, 34, Russell Square, W.C., 7.30 p.m. (Junior Members' Meeting). Mr. H. A. Robertson, "Some Notes on the Assessment of Delapidations."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. D. S. Watson, "Evolution To-day." (Lecture II.)

Mechanical Engineers, Institution of, The University, Edmund Street, Birmingham (Midland Section), 7.30 p.m. Mr. C. H. Petford, "Economic Considerations on the Generation of Steam for Power Purposes."

University of London, King's College, Strand, W.C., 5.30 p.m. Prof. W. W. Buckland, "The Classic Roman Law; Recent Investigations." (Lecture II.)

Chemical Society, Burlington House, Piccadilly, W., 4 p.m. Annual General Meeting. Address by the President, Prof. W. P. Wynne.

FRIDAY, MARCH 28 ... Engineering Inspection, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m. 1, Annual General Meeting. 2, Mr. H. B. Spencer, "Inspection Clauses in Engineering Specifications."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Joint Meeting with the Institution of Civil Engineers to discuss report on Standard Tests for Hydraulic Power Plants."

Royal Institution, Albemarle Street, W., 9 p.m. Dr. H. Maclean, "Insulin."

Chadwick Lecture, Council Chamber, Old County Hall, Spring Gardens, S.W., 8 p.m. Mr. J. T. Quinton, "The Sanitary Inspector in the Machinery of the Public Health Service."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Capt. A. G. Buckham, "The Way of the Lovely Sky."

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Engineers, Junior Institution of, 39, Victoria Street, S.W., 7.30 p.m. Mr. A. J. Simpson, "Wood Wall: its Manufacture and Application."

Chemical Industry, Society of, at the Institution of Civil Engineers, Great George Street, S.W., 6 p.m. Mr. L. Andrews, "Kinetic Electrication."

(South Wales Section), Technical College, Swansea, 7.15 p.m. Address by Captain H. Vivian.

(Glasgow Section), 39, Elmbank Crescent, Glasgow, 7.15 p.m. Dr. J. A. Cranston, "The Influence on Chemistry of the Recent Knowledge gained from Atomic Structure."

SATURDAY, MARCH 29 ... London County Council, at the Horniman Museum, Forest Hill, S.E., 3.30 p.m. Mr. S. H. Warren, "Prehistoric Man and the 'Land of Lyonesse.'"

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FRIDAY, MARCH 28, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 31st, at 8 p.m. (Cobb Lecture.) DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." (Lecture II.)

WEDNESDAY, APRIL 2nd, at 8 p.m. (Ordinary Meeting.) SIR LYNDEN MACASSEY, K.B.E., LL.D., D.Sc. (Secretary to the Royal Commission on London Traffic, 1903-7), "London Traffic." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

FRIDAY, APRIL 4th, at 4.30 p.m. (Extra Meeting.) GEORGE MACAULAY BOOTH, Director of the Bank of England and of the Booth Steamship Company, Ltd., "The Amazon Valley and its Development." H. E. THE BRAZILIAN AMBASSADOR will preside.

[A collection of specimens illustrating the resources of the Amazon Valley will be on view in the Library from Friday, April 4th, to Thursday, April 18th.]

Further particulars of the Society's meetings will be found at the end of this number.

COUNCIL.

A meeting of the Council was held on Monday, March 10th. Present:—

Lord Askwith, K.C.B., K.C., D.C.L. (in the chair), Lord Bearsted, Mr. C. F. Cross, F.R.S., Sir William H. Davison, K.B.E., D.L., M.P., Mr. Edward Dent, M.A., Rear-Admiral James de Courcy Hamilton, M.V.O., Major Sir Humphrey Leggett, D.S.O., R.E., Dr. William H. Maw, M.Inst.C.E., Mr. John Slater, F.R.I.B.A., Sir George Sutton, Bt., Mr. James Swinburne, F.R.S., Dr. J. Augustus Voelcker, M.A., and Sir Philip Watts, K.C.B., LL.D., F.R.S., with Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

On the motion of Lord Bearsted a vote of condolence and sympathy with Sir Philip Magnus, Bt., on the death of Lady Magnus, was passed.

Lord Askwith was appointed to represent the Society on the occasion of the Jubilee Celebrations of the Physical Society of London on March 20th to 22nd, and at the Kelvin Centenary Celebrations in London on July 10th and 11th next.

Sir Frank Baines, C.V.O., C.B.E., was nominated as the Society's delegate at the conference organised by the British Association for the Advancement of Science to consider further protection of sites of historic interest or of natural beauty against disfigurement or obstruction.

Arrangements for papers and lectures were considered.

Other formal business was transacted.

FIFTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 19th, 1924; LORD CLINTON, Forestry Commissioner, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Agnew, Andrew, C.B.E., London.
Anderson, Percy, M.B.E., Gerrard's Cross, Bucks.
Lundie, John, D.Sc., New York City, U.S.A.
O'Brien, Arthur Matthew, F.C.S., Skewen, Glam.
Parker, Charles, Nottingham.
Summers, Daniel Henry, Portsmouth.
Verma, Banwari Lall, Delhi, India.

The following candidates were duly elected Fellows of the Society:—

Arnold, James Ernest, F.R.G.S., London.
Bethell, Lieut.-Colonel L. A. B., Landi Kotal, N.-W.F. Province, India.
Bhatia, G. R., Dehra Dun, India.
Hall, A. G., Assoc.M.Inst.C.E., Landi Kotal, N.-W.F. Province, India.
Raley, Captain George Giles Emsley, B.A., M.C., Toronto, Canada.
Roberts, Lieut.-Colonel Sir James Reid, C.I.E., F.R.C.S., London.

A paper on "The Forests and Timber Supply of North America" was read by MR. R. L. ROBINSON, Forestry Commissioner.

The paper and discussion will be published in a subsequent number of the *Journal*.

INDIAN SECTION.

FRIDAY, MARCH 21st, 1924; LORD LAMINGTON, G.C.M.G., G.C.I.E., in the Chair.

A paper on "The Progress of Co-operative Banking in India" was read by MR. OTTO ROTHFELD, I.C.S.

The paper and discussion will be published in a subsequent number of the *Journal*.

COBB LECTURE.

MONDAY EVENING, MARCH 24TH, 1924; DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, delivered the first lectue of his course on "Certain Fundamental Problems in Photography."

The lectures will be published in the *Journal* during the summer recess.

VISIT TO THE GUILDHALL.

On behalf of the Fellows of the Society and their ladies, the Council have gratefully accepted an invitation from Mr. H. G. Downer, LL.B., a member of the Common Council, to inspect the Guildhall, including the Art Gallery of the Corporation of London, on Thursday, May 8th at 2.30 p.m.

Sir Alfred George Temple, F.S.A., will act as escort in the Art Gallery and Mr. Deputy Alderton, C.C., in the Council Chamber, Crypt and other places of interest in the Guildhall.

Fellows desirous of availing themselves of the invitation should inform the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.2., on or before May 3rd, mentioning the number of their party.

Those attending are requested to assemble at the main entrance to the Guildhall in King Street, Cheapside, at 2.30 p.m.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, MARCH 4TH, 1924.

THE RT. HON. LORD BEARSTED in the Chair.

THE CHAIRMAN said that before he called upon Mr. Cochrane to read the paper he had prepared, he would like to say that Sarawak was a field that inspired enthusiasm because it commemorated those traits which had made England what she was. Sarawak was brought into prominence by Sir James Brooke, a popularly-elected chief, elected by the natives who could not rule themselves, but who knew the great traditions of the British Empire in founding colonies. Therefore, the lines followed in the establishment of Sarawak were very much like those of the old East India Company—private enterprise, and the flag following. The development of the oilfields in Sarawak was another creditable achievement of the same kind. The company who had developed Sarawak was chosen by the late Sir Charles Brooke to do it, because they had a reputation in which he believed. How great the enterprise was the audience would realise as the paper was read. They entered upon it entirely unassisted by any Government and not dependent on any Government either. The result had been one of which the Empire might be proud, and which, if he was not mistaken, would make Sarawak one of the brightest jewels in the crown of the British Empire.

The paper read was:—

EMPIRE OIL: THE PROGRESS OF SARAWAK.

By the HON. T. G. COCHRANE, D.S.O.

On April 11th, 1923, a very interesting paper on "Sarawak, its Resources and Trade," by Mr. E. Parnell, was read before the Society. In this, however, only a brief mention was made of the petroleum industry, and it is the purpose of the present paper to amplify the information then given.

The production of petroleum in Sarawak in 1923 was about 560,000 tons, and though this is not large in comparison with, say, California or Mexico, it has this point of special interest and importance—that it is produced within the Empire. "The Oil Resources of the British Empire" was the subject of a paper read before the Society by Sir John Cadman on June 4th, 1920. In this the production from Sarawak for 1918 was given as 80,000 tons, making it a very bad fifth in the list of producing countries within the Empire. To-day Sarawak can claim to be by no means a bad second—the lead, of course, still being held by the great oilfields of Burma, the work of many years of development.

The presence of oil seepages in the neighbourhood of the Baram and Miri Rivers had been known for many years before any active steps were taken to investigate the possibilities of obtaining a commercial production from them.

A series of more or less active seepages, located a little inland from the original Miri village, were actually exploited in a primitive way by the Miri Malays. The

procedure was to dig pits about three feet deep in the zone of seepages. Being in swampy ground these pits filled with water on the surface of which the oil floated. This oil was skimmed off by the natives using gourds or cocoanut shells, and burnt for lighting their huts in very primitive lamps, made from any convenient vessel, such as an empty tin, a small gourd or even a bottle, using a strip of cotton or other cloth to serve as a wick.

The bituminous residue or asphalt which was found at the seepages (the result of evaporation and oxidation) was also used by the natives for caulking their dugouts. Later the use for this purpose of damar, an indigenous resin, and the importation of kerosene oil combined to make the working of these seepages less advantageous, and interest was gradually lost in them.

In the year 1909, however, the Anglo-Saxon Petroleum Company became sufficiently interested in the possibilities of the Miri district to make an application to the Rajah of Sarawak—the late Sir Charles Brooke, G.C.M.G. — for a concession to exploit the oil resources of Sarawak.

The Rajah in due course granted to the company a concession on terms which were fair and satisfactory to both parties. One particular stipulation which the Rajah did make, and one which will commend itself to all subjects of the British Empire, is contained in Clause 14 of the Concession, which reads as follows: — "The Company hereby covenants that during the continuance of the licences hereby granted it will not export any of the said mineral products which can be safely used as liquid fuel, so as to leave a quantity of less than 10,000 tons (English measure) stored in the district aforesaid, and further that such quantity of ten thousand tons of liquid fuel shall be used only for the purpose of supplying the ships of the Navy of Great Britain or any of her Colonies." The only exceptions which have been made in the carrying out of this patriotic wish of the Rajah have been that, for a period during and directly after the War, with the consent of the Rajah and the Admiralty, fuel oil was stored at Singapore instead of at Miri; and that naval vessels of our Allies the Japanese were included in those which could be supplied from that 10,000 tons of Sarawak oil.

As a result of this concession being obtained it was necessary to arrange for a Geological Examination to be carried out. The geologist chosen for this purpose was Dr. J. T. Erb, now a Director of the Anglo-Saxon Petroleum Company.

Between August and December, in the year 1909, Dr. Erb carried out a rapid reconnaissance survey in the northern part of Sarawak, covering some 400-500 miles, and was able to report the existence at Miri of a dome-shaped, unsymmetrical anticline, with a steep Eastern flank and numerous oil shows. He received very cordial assistance from the Sarawak Government officials.

In February, 1910, Dr. Erb returned to Miri, and after further investigation of that area, fixed the location of the first well.

In March, 1910, the first definite steps were taken which laid the foundations for the present successful petroleum industry of Sarawak. Mr. McAlpine, a Canadian, was selected from one of the already established oil fields in the Dutch East Indies to proceed to Miri and ascertain what material, labour and foodstuffs would be required, and what could be obtained locally. It may be mentioned here that Mr. McAlpine is still at Miri, occupying the responsible position of Field Manager, and that much of the success that has been achieved may fairly be attributed to his efforts.

At the time of Mr. McAlpine's first visit the village of Miri, together with that of Pujut, could only muster about 80 able-bodied men and youths. For provisions there were two Chinese stores, whose whole stock consisted of a few tins of bully beef; everything else had to be imported. The Sarawak Government officials who were consulted reported that the coast was unapproachable from September to March on account of the monsoons, and that it was advisable to lay in a stock of provisions to last for at least six months during that period.

Mr. McAlpine returned to Singapore, where 25 Chinese coolies were obtained and a 50-ton lighter was bought. This lighter was packed with stores and towed to Kuching, where a further labour force of 10 Malay carpenters and 20 coolies had been recruited.

At this time there was no regular communication between Kuching and Miri by sea, but it was arranged with the Government that one or other of the old paddle steamers which then ran between Kuching

and Limbang should call once a fortnight at Miri on the outward voyage. The lighter was towed from Kuching to Miri by one of these boats, arriving there at the end of April.

There was no accommodation available at Miri, and all hands set to work to build shelters for the Chinese coolies, the Malays being billeted on the natives. It is pleasant to record that these pioneers of a new industry in Sarawak had a most friendly reception from the natives, and were given every help and encouragement by the Sarawak Government officials. The rig irons, boilers, engines and drilling tools were dispatched from the Sanga Sanga field in the Dutch East Indies in charge of Mr. Souter, an English driller, and arrived at Miri early in May.

Great difficulties were encountered in bringing the material ashore; the only landing place was inside the Miri river, and the only means of propulsion for the lighter was by punting it with poles. As the river current was rather strong it was necessary to take the lighter to sea on an ebb tide and bring it back on a rising one. The bar of the river is shallow, has no shelter, and only about a foot of water over it at low water spring tides, so that the operations had to be nicely timed to avoid sticking on the bar with a valuable cargo, at the mercy of any sudden storm that might arise. In spite of these difficulties, however, by August nearly the whole of the drilling material and six months' provisions had been safely landed without any serious mishap.

The site for the first well was located about a mile from the landing place, 260 feet above sea-level. The drilling boiler took 80 men with blocks and tackle three days to haul into position. Drilling commenced on August 10th, the wire line and poles method, which had proved very successful in the Dutch East Indies, being used.

Exactly two months later, on October 10th, oil was struck at a depth of 447 feet, and the well produced 4 tons of water-free oil per day. It was then deepened slightly to 510 feet, from which level it produced 12 tons a day. The arrival of the fortnightly steamer from Kuching was anxiously awaited to enable a cable to be sent to London announcing this favourable result. The weather was stormy and no steamer appeared, so Mr. Souter volunteered to go on foot to Brunei, some 90 miles by the coast route. He arrived in Brunei in four days, whence he took a launch to Labuan Island where there was a cable station, and the good news duly reached London that oil in commercial quantities had been found in Sarawak.

I have devoted some time to describing the initial difficulties which were met with and how they were overcome, and though it may be thought that all thereafter would be plane sailing, it must be remembered that the mere capacity to produce oil is of itself of no value commercially, unless it can at any rate be stored as it is produced, and, still more important, shipped to some market where it can be sold. The progress which was made and the steps which were taken to meet these essential requirements, I now propose to describe. I will commence by giving some details of the extension of the Miri field after the bringing in of the first well.

The success of the first well, of course, necessitated its being shut in until storage could be erected. A second well was commenced in April, 1911. In September, Mr. H. Wyndham Jones, the first General Manager, arrived and took charge of the operations. He remained at Miri until 1920, when he was able to hand over to the present General Manager, Major E. V. Benjamin, M.C., a vastly larger and more important enterprise than he had found nine years previously. The first steel storage tank of 4,500 tons capacity was completed in October and the production for the year was about 260 tons.

In 1912 drilling was continued with only a moderate amount of success, the total production for the year being 5,635 tons. During the year a small distillery was constructed from old steel oil drums, and the crude oil treated to produce a straight run benzine of .760 sp. gr., an intermediate kerosene product and a fuel oil of .900 sp.gr., which was used in a steam launch. The benzine produced was taken over by the Sarawak Government for use locally in street lamps and motor launches. Two further tanks of 4,500 tons capacity each were also completed. By the end of the year the staff comprised 19 Europeans and a native labour force of 424 Malays and Chinese.

During 1913 drilling proceeded energetically, but no very good wells were completed in the Miri field itself. A probable extension of the Miri field to the north, however,

had long been recognised, and well No. 8 was located at Pujut, and at a depth of 1,402 feet came in flowing at a rate of 80 to 100 tons a day. The production for the year was 26,067 tons and the staff had increased by the end of the year to 26 Europeans, with 764 natives and Chinese.

On April 18th, 1913, the first shipment of Sarawak oil was made in two lighters, which were towed away from the Miri River. The experiment was also tried later on of mooring a tanker off the Miri River to act as a floating storage tank. This, however, was not altogether a success, as the weather often made it impossible for a tanker to go alongside, and lighters had still to be used.

In 1914 further successful wells were drilled, although none of them were very large producers. The total production for the year was 64,510 tons, and the staff had increased to 29 Europeans with 969 natives and Chinese.

In August of that year the first attempt was made to lay a submarine pipe line through which oil could be pumped to a tanker lying at anchor in deep water. The proposed method was to float the line out in three sections, each about 4,500 feet long. The pipe line was of 6 inches diameter, and the position of the shore end was about 500 yards south of the mouth of the Miri River. Soundings showed that to reach a depth of 24 feet of water a length of about 13,500 feet would be required. It was intended to tow the sections out in succession and couple them together with specially prepared short lengths of pipe as each section left the beach. The only reason for adopting this method of launching in sections rather than towing the whole line out in one piece, as was done with the lines subsequently launched at Lutong (of which a description will be given later), was this: the maximum length of level ground available at the spot selected was 4,500 feet, and thus to reach a depth of 24 feet of water three sections of line, each 4,500 feet long, had to be prepared on separate runways and towed out in succession.

The first two sections were floated out successfully, but whilst the second and third sections were being connected up a sudden squall caused enough sea to get up to break the floating line some 200 feet from the beach. All hope of connecting up the third section was abandoned, and the floats, consisting of 8-gallon drums tied to the pipe at intervals, were cut away and the line allowed to sink to the bottom. The depth of water at the sea end was about 18 feet, which was sufficient for the time being. In spite of trouble with the flexible hoses which frequently broke, 22,755 tons of oil had been loaded into tankers through the line by the end of the year.

At the beginning of 1915, as was to be expected, and indeed down to the end of 1919, operations at Miri were much handicapped by shortage of materials and staff, and to an even greater extent by shortage of shipping and storage.

In October, 1916, a topping plant on the Trumble system was completed on a site about 500 yards south of the Miri river. This had a capacity of 500 tons a day, but in view of the war conditions, was only operated to produce fuel oil and distillate. During the time in which it was in operation in 1916 it produced 10,464 tons of liquid fuel. The existence of the topping plant enabled fuel oil to be produced for the Navy, but this could not, of course, be produced without also producing a distillate, consisting of the lighter fractions for which there was no demand under war conditions. At a time when every tanker was urgently required for the transport of fuel oil or benzine to some theatre of war, it was seldom possible to spare one for the carriage of distillate.

Under these abnormal circumstances an abnormal course had to be adopted. Distillate had to be produced; it was not wanted for war purposes, and the limited storage capacity was required for crude oil and liquid fuel. We have all heard, I suppose, how in pre-motor car days benzine, i.e., petrol, was regarded by oil producers as a dangerous and undesirable waste product at a refinery, and how in consequence it was burnt in huge quantities to get rid of it. The Sarawak Distillate, however, did not share this fate, but instead, the novel plan, which originated in the fertile brain of the Chairman of the Company, was adopted of pumping it back again into the earth from which it had come. Certain wells were selected, which were known to have almost exhausted the oil sands into which they had been drilled, and about 30,000 tons of distillate was pumped back into them, the pump pressure at times rising to over 100 pounds to the square inch. Later on, in 1919, when storage

and shipping conditions had become more normal, these wells were pumped again, and I am pleased to say that it is estimated that about 14,000 tons of distillate was recovered in the form of a light crude.

The total amount recovered was probably in excess of this, as the migratory powers of oil are well known, and there were evidences of this in the lighter crude which was produced from certain wells some distance from those whose production, or rather re-production, was actually measured.

By the end of 1915 the condition of the 6 inch submarine pipe line had become so bad that it was decided to lay an 8 inch line at once. The comparative failure of the first line, and the fact that Pujut had become quite an important producing centre, both pointed to the desirability of adopting the methods of launching which had already been successfully employed in Mexico. This necessitated a stretch of level ground running inland from the sea to a distance equal to the length of the required submarine line. At Miri itself, as has already been stated, there was no such stretch of ground available, but at Lutong, some seven miles to the north, there was ample space. It was also recognised that the promontory and sand banks at the mouth of the Baram River would give considerable protection against the N.E. monsoon to tankers lying off Lutong, and soundings shewed that a greater depth of water could be obtained at a reasonable distance off the shore at Lutong than at Miri.

The first 8-inch line was successfully launched in September, 1916. The length was 11,750 feet, giving a depth of water at the sea end of 28 feet at low water spring tides. This line is still in use, and three further lines have since been laid, a description of which will be given later. The line was at once taken into use and oil pumped to it from the refinery at Miri.

It was, of course, obvious that sooner or later the refinery would have to be moved from Miri to Lutong, so as to be near the tank farm and sea loading line. An additional reason was that, as originally erected at Miri to act as a topping plant, a gravity flow through had not been arranged for. Actually, owing to war conditions, the transfer was not commenced until December, 1918, and the refinery was able to start up again at Lutong in July, 1919.

As I have already pointed out, the progress of Sarawak during the period of the War, and for at least a year afterwards, was much hindered by a serious shortage of staff and materials of all kinds.

The years 1919, 1920, 1921 were devoted mainly to what I may term the consolidation of the position already gained, and in building up the necessary resources in staff and materials to make possible the greatly increased production reached in 1922. Thus while 1919 shewed an increase over the previous year of 13,000 tons, 1920 an increase of 60,000 tons, and 1921 an increase of 58,000 tons, the year 1922 was able to shew the remarkable increase of 204,000 tons—more than twice the production for 1921. The year 1923 has again shown a very marked increase over 1922 of some 150,000 tons.

The slide on the screen shews the present Miri field. The first wells, it will be seen, were drilled rather close together and were mostly shallow. Well No. 1 I am glad to say is still producing about two tons of oil a day, while well No. 8 at Pujut, which was the first well to produce 100 tons a day, is also still producing some 18 tons a day.

A better knowledge of the geological structure, the result largely of a careful record of all well logs having been kept from the very beginning, has enabled deeper drilling to be carried out successfully in areas where the shallow sands of the original field were not found to be oil-bearing. The structure, as far as is known at present, comprises three anticlines with a N.E.-S.W. strike more or less in echelon.

Recent deep drilling to the south of the old field has also given favourable results, so that a further extension of oil-bearing structure in that direction is anticipated.

Extended geological examinations of other parts of the State have revealed many surface indications of oil, but drilling results have not so far been successful in obtaining oil in commercial quantities. Further test wells are now in course of drilling, and it is hoped that a further field or fields will be proved.

Drilling and production methods call for no particular comment. They are, generally speaking, up-to-date, and every possible use is made of the gas produced on the field, both under drilling boilers and for operating gas engines at the various pumping stations.

All wells are now drilled with cable tools

and Californian pattern rigs. The depth of wells varies from a little under 1,000 to over 2,000 feet, and tests are now being made for deeper sands in the same area.

At Pujut a shallow field has been developed with wells from 300 to 400 feet deep, which produce a natural fuel oil with no constituents boiling below 200°C. This crude is pumped direct to fuel oil storage tanks, so that if the Lutong refinery was completely destroyed to-morrow a certain amount of fuel oil would still be available for naval or other purposes.

To the south of the old Miri Field exploration wells drilled recently have given good results at over 2,000 feet, producing a crude oil with a higher percentage of light fractions than are obtained from other parts of the field.

A few wells have continued flowing for long periods, but most of them are pumped. Central pumping powers operated by gas engines are extensively used for pumping groups of wells, showing, of course, a very great economy over the pumping of individual wells by steam engines.

Wells in the Miri Field have, generally speaking, a long life, and a typical production curve shews that after a rapid fall during the first year the decline after that is at comparatively a very slow rate.

The refinery at Lutong at present comprises two units working on the Trumble system of distilling oil by means of tubular stills, with a combined throughput per 24 hours of about 1,500 tons of crude oil, while a third Trumble unit is in course of erection. There is now a sufficient supply of gas from the field to enable the whole refinery to be run on gas instead of on fuel oil at night-time, when the requirements of the field are low.

The properties of Sarawak crude oil were described in a recent paper read by Mr. James Kewley before the Institution of Petroleum Technologists, and I am indebted to him for the following chemical details, which may be of interest.

The crude oil is a mobile liquid of the naphthenic type, reddish brown in colour and of an agreeable odour. Its chemical nature has not yet been fully investigated, but sufficient work has been done on this oil to shew that it is of a very interesting type, and that it presents many possibilities for scientific research and technical development. This is particularly the case with regard to lubricating oils.

The products of the Miri crude at present being handled at the Lutong refinery are as follows:—

(1) A benzine of final boiling point 200°C. being about 14 per cent. of the crude. This benzine when tested in a variable compression engine has been found to withstand a compression ratio of 5.3 to 1, without appreciable detonation, *i.e.*, without what motorists call "pinking," and is therefore a valuable product.

(2) A kerosene of rather high specific gravity, which after refining can be used as a lamp oil, though not of the highest class, its best use being for internal combustion engines of the hot bulb or semi-diesel type.

(3) A fuel oil of Admiralty quality and with a low setting point having the following properties:—

Specific gravity at 15°C. ..	about 0.930
Flashpoint P.M.	175°F.
Viscosity Redwood 1 at 70°F.	75 seconds
Viscosity Redwood 1 at 100°F	49 seconds
Pour test A.S.T.M.	below 20°C.
Sulphur	0.4%
Ash	0.01%
Conradson Coking Test ..	0.7%

The residual fuel oil is thus in every respect a good fuel, not only for burning under boilers, but also for use in Diesel engines.

Having now given a short account of how Sarawak oil is produced and handled, and of the products from the Lutong refinery which are available for shipment, I would like to call your attention to the methods by which they are shipped.

The sea-loading lines at Lutong are the longest in the world, and are therefore perhaps of sufficient interest to merit a short description both of them, and of the methods by which they are constructed and laid down.

The particulars of the four lines which are now in use are as follows:—

	No. 1.	No. 2.
Launched	Sept. 1916	April, 1919
Length	11,750 ft.	13,000 ft.
Depth (L.W.O.S.T.)	28 ft.	32 ft.

	No. 3.	No. 4.
Launched	Aug., 1921	Sept., 1923
Length	14,500 ft.	14,510 ft.
Depth (L.W.O.S.T.)	36 ft.	36 ft.

The third sea-loading line, launched in August, 1921, may be taken as an illustration of the methods employed, with slight variations, in the construction and launching of all these lines.

In view of the larger size and consequently deeper draught of modern tank ships it was thought desirable to secure a depth of water at the loading terminal of not less than 35 ft. at low water. Soundings showed that to obtain this depth a length of about 14,500 feet ($2\frac{3}{4}$ miles) would be required.

A clearing was first made through the jungle in a straight line for $2\frac{3}{4}$ miles from the shore to a width of from 8 to 10 yards. The actual width of the track necessary for the pipe itself, of course, is only a few feet, but the risk of a heavy tree falling on the line, possibly when just ready to be launched, has to be guarded against at all costs, and all big trees which would be a source of possible danger were also felled.

The ground at the back of Lutong is all flat, though swampy, and a considerable amount of bridging was necessary to carry the track across streams and ditches. As soon as the track was completed and levelled a light railway was laid down with a two foot gauge, referred to as the "runway." The steel pipe of 8″ diameter was then distributed along the runway, making use, of course, of the rail track for carrying it. The next step was to screw the lengths of pipe together and mount the joined lengths on a series of small trucks distributed along the runway track at intervals of about 18 yards. To give additional strength to the sea end of the line, which would have to bear the towing strain during launching, the first 12 joints were reinforced with "river clamps," *i.e.*, long sleeves made in two halves longitudinally and bolted on to the pipe over the threaded couplings. After a careful inspection and hydraulic test the pipe was given a heavy coat of hot bitumastic anti-corrosive composition, and then wrapped round with a kind of roofing felt secured in position with binding wire. On top of the felt came another coating of bitumastic and then lengths of "nebong," a sort of palm, split into lengths of 20′ or so were fastened lengthwise to the pipe and securely bound in position with wire. The object of all this wrapping is, of course, to protect the steel pipe from the corrosive action of sea water, while the nebong battens protect the pipe covering from the abrasive action of the sea bottom over which it has to be dragged.

The total weight of the line ready for launching was about 230 tons.

Further preparations for launching entailed bolting an eye to the end of the pipe to receive the shore end of the towing hawser, and the construction on the shore of massive timber guide-posts fitted with rollers to keep the line as straight as possible. To keep the end of the pipe as much as possible from embedding itself in the sea bottom, a number of empty airtight drums were lashed to it. Some means, of course, had to be adopted to ensure the pipe as it moved into the sea coming away from the trucks on which it rested. Actually a method was used by which the trucks left the pipe; on the shelving shore the runway was made to dip steeply and the track diverted to the left. In this way each truck as it reached the dip came free from the pipe and was run down a siding out of the way of the other trucks.

A signal mast and control platform were erected over the sea end of the line, giving a clear view of the towing ships and of the whole length of the line. A code of signals was arranged whereby the movements of the towing ships could be controlled from the shore, and the towing started and stopped or accelerated and slowed down as occasion required.

When all preparations had been made the launch was arranged for H.W.S.T. on a fine calm day.

A staff of 220 men in charge of 10 Europeans were distributed along the runway to prevent derailments. Telephone stations in direct communication with the Signal Station, each with a European in charge were established at the 5,000′ and 10,000′ marks, so that in the event of a derailment or accident towing could be stopped immediately.

The very great importance of making the most elaborate arrangements for control during the actual period of launching will be appreciated when it is remembered that, while the construction and preparation of the runway and pipe line take many months, the actual towing out of the line may take less than an hour.

A towing hawser some 6,000 feet long was secured to the eye at the end of the pipe line, and laid out by launches and

barges until a depth of water was reached at which it could be hauled on board a tug, which with a tanker, had come as close in shore as possible.

On a signal from the shore being given the tug and tanker commenced steaming ahead on a course marked with buoys.

Once the line was started it moved evenly forward at an average rate of 3.17 knots, no derailments occurred, and the stop signal was only hoisted when some 14,500 feet of line had been successfully launched.

To complete the submarine line for service 120 feet of flexible hose 8″ diameter in 20 feet lengths is coupled to the sea end of the line by a diver and the other end attached to a buoy. Tankers arriving to take a cargo are moored as shewn on the slide. The actual position of some of the buoys depends on the prevailing wind at the time of year. The flexible hose is hoisted on board over the stern together with a submarine telephone line, which is in direct communication with the pump station on shore. Orders to commence and stop pumping are given both by telephone and by signal, thus giving additional security against misunderstandings between ship and shore.

In spite of the great length of the submarine lines and the exposed position of the sea loading station in certain winds, their operation has been very successful, and during 1923 115 ships were loaded or bunkered without any mishaps or serious delays.

The approximate rate of loading for different products through these lines is: Liquid fuel, 190 tons per hour; benzine and kerosene, 140 to 150 tons per hour.

The total quantity of oil loaded through the submarine lines in 1923 was about 530,000 tons.

Sarawak Oilfields, Ltd., which now operates the petroleum industry of Sarawak, is a company incorporated in Sarawak, with its registered office there, and with two representatives of the Sarawak Government on its Board of Directors.

From the figures which I have given of production it will be appreciated that a large staff both of Europeans and of Asiatics is required. At the end of 1923 there were 133 European employees, with 42 ladies and 39 children. Also 190 senior Asiatic staff and 3,252 coolies. Miri itself has long ceased to be a primitive native village, and now possesses motor roads, railways, electric light, an automatic telephone exchange, far in advance of anything provided by the post office in London, clubs for European and Asiatic staff, a soda water and ice-plant, a farm producing milk, eggs, beef, mutton, etc., a cinema, a school for European children and another for Asiatic children, a church, a golf course, and cricket, football and baseball grounds.

The company also operates a large sawmill on the Bakong river, a tributary of the Baram river, which produces large quantities of timber both for building purposes and for the construction of drilling rigs.

From the information which I have given as to the progress of Sarawak, it will, I think, be seen that it has now an established petroleum industry which has made great strides in the last few years, and which it is hoped will continue to increase in importance as a producer of oil within the British Empire.

DISCUSSION.

THE CHAIRMAN (Lord Bearsted), said that he thought all those present would agree with him, after having heard the paper, that the subject was a very inspiring one, and showed that the age of romance was not dead yet. He wondered how many of them thought, when they travelled either in the motor car or the omnibus, of this fuel which nature had provided, and which had been in the ground for perhaps thousands of years in remote parts of the world, but which had now been brought to the surface and conveyed these thousands of miles for the use of civilisation. Perhaps the audience would agree with him that the men who went out on these ventures and made far more than two blades of grass grow where one grew before, were benefactors to the world, and, if he might say so, deserved the success they attained in the shape of any monetary reward which could be got from petroleum exploration.

There were two subjects embodied in the paper, one of them Empire oil, and the other the progress of Sarawak. He proposed in speaking to reverse this order and to deal with Sarawak first, and with the question of Empire oil second. Many instructive incidents relating to the development of Sarawak had been mentioned by the author. He had spoken of the enormous advantage of experience gained in other fields for those who would attack new ones. Then they had heard of the abnormal course that had to be pursued when the output of light products accumulated, owing to the impossibility of shipping them during the war. He thought it might be of interest if he gave the Society the financial results that ensued. Thirty thousand tons of petrol were, roughly speaking, worth about £450,000, and it required some courage to adopt a method which had never been tried before;

but the alternatives were so serious that he was glad the thought occurred to himself, as Chairman of the Company at that time, to suggest to those on the spot that as the earth was the cheapest and safest form of store, the experiment should be tried of putting these superfluous products back into the earth. They had heard from the paper that it was a success, and he ventured to say that that was of great moment for those who had to deal with eruptive wells, occasionally giving an enormous supply which swamped the country, and instead of being a blessing were a bane. As a result of that experiment at Sarawak, they now knew that they could put the product of those superfluous wells back into the exhausted ones, and yet be able probably to recover a good deal of the product afterwards when they required it.

Another point arising from the paper was the question of refining on the spot. The author had told them that there was a sufficient supply of gas from the fields to enable the whole of the refinery to be run on gas instead of fuel oil when the requirements of the field were low. Could anything be imagined more unwise than to remove oil which could be refined at the point of production and take it away for refining purposes, as was done in some cases to a distance of thousands of miles? The only possible reason for that unnatural proceeding must be political, and those Governments which imposed very high rates upon refined products and allowed crude products to be brought in not free of duty, but at a low duty, failed to recognise the economic loss which was caused by those proceedings, or he thought they would alter them. They had a great deal to be thankful for that certain neighbouring countries had pursued that course, because the progress of mechanical traction depended upon a large and cheap supply of fuel, and that was not possible, and never would be where uneconomic methods were used to produce it. The oil obtained at Pujut was quite extraordinary in its character. It was a natural oil, and in common with an oil produced in the centre of the Dutch East Indies, it was a solvent, when met with too resinously. There were few petroleum-sources in which light fractions were able to be taken off and a good liquid fuel to be left. In the great majority of such cases, the taking off of the light products left a fuel of such great viscosity that it was impossible to use it, but this company had the advantage that a mixture of that fuel with heavy fuel made the latter marketable. Again, the quality of the oil was such as to enable it to be used in Diesel engines, and that was very important, because the Diesel-engine ship was the ship of the future. The tonnage now building throughout the world showed that nearly 40 per cent. of the vessels under construction were for the internal combustion engine, and the production of oil was of enormous importance, because, used for internal combustion, it represented an economy of nearly 3 to 1 compared with using it under the boilers. The latter was a barbarous method of using the material, and he wondered what their successors a generation or two hence would say with regard to the foolishness of those in the past who had burned oil. It was satisfactory to know that at Sarawak there was a depth of water at the loading terminal of 35 feet at low water, which meant that the largest ships afloat could bunker there.

The Sarawak Oilfields, Limited, which now operated this field, was a company under the laws—the liberal laws—of Sarawak, where, he believed, the income tax was unknown, and where directors, contrary to the methods in our own country, which ought to be altered, were at liberty to make proper appropriations for depreciation without let or hindrance. It was a pitiful thing that companies here were not allowed to make sufficient allowance for depreciation, but were charged income tax, not only on the supposed profits, but also on sums which should be put to depreciation, and which, in an oilfield, represented a real consumption of capital. It was quite true that they received the proceeds of the oil, but it had to be remembered that that oil was never replaced; it had disappeared, and it should be written off as part of the capital if the company was to operate under the very best auspices.

The author had told them that Miri was no longer a native village, and it would have been seen from the photographs that every amenity that the Directors of the company could afford was willingly given to the town. He knew the work of that Company; he could speak of it in a spirit of detachment, because he left it three years ago, and was now not in business at all, and he could say that the Directors had made it their business to see from the start that the employees who were carrying the flag abroad should have the best conditions in which to live and work, and should be provided for in their old age by the establishment of a large provident fund in which all of them shared. After a certain number of years all the employees in that company would find themselves amply provided for.

The geographical position of this field had been illustrated by means of maps, but it was very difficult to gather from them how important it was. That this field was an immense asset to the British Empire none would dispute. The distance from Singapore was only 630 miles, less than three days' steam, and the distance of any other source from Singapore (except the Dutch East Indies, which was very close) was 3,938 miles. In the light of these distances, the importance of this field to the British Empire would be better realised. From Hong Kong the distance was 1,080 miles, and the representative of the Japanese Navy, who was present in the audience that afternoon, would be interested to hear that the distance from Yokohama was only 2,600 miles, while the distance from Yokohama to San Francisco, the next nearest source, was 4,550 miles. Thus they would see that it was a matter of very great moment that the geographical advantages of this position should be realised. Personally he felt persuaded that the distribution of oil would, in

the future, be guided by the proximity of the bases of production, and they would not see the terribly wasteful methods of transport which now prevailed, wherein oil was brought from very great distances, when it might be obtained quite near at hand. That was particularly appropriate to Australia. Sarawak was only 4,350 miles from Newcastle, N.S.W., and 4,430 miles from Sydney. The Australian Government—he assumed before they were aware of the large production likely to be forthcoming from Sarawak—had arranged for their supplies from another source, from which Newcastle was 7,740 miles distant, and Sydney 7,522 miles. Therefore, Sarawak was splendidly placed for supplying the needs of neighbouring countries. All this, of course, had its political aspects too. The bearing of the development of this field on the Singapore base was a very important one indeed. The Admiralty, of course, knew its business thoroughly, but probably it was not realised that a field had been found in British territory, and, of course, under British control, only three days' steam away from Singapore. The question of the protection of Sarawak was an extremely important one from that point of view, because it was inconceivable that we could ever allow that wonderful field--as he believed it would be found to be—to fall into enemy hands. He did not like to envisage an enemy in those waters. He had seen the evils in the oil scandals which had arisen lately in the United States, where it was argued that Hawaii was a necessary port for the American Navy, in view of the fear of an alliance between Great Britain and Japan to attack the United States. That was a midsummer madness. He declined to believe—although he supposed they must provide for every contingency—that they were going to see any alliance of that kind, any more than an alliance of the United States and Japan for the purpose of invading the British Colonies. He did not believe in it one bit.

He now came to the question of the development of oil in the British Empire. As one who had made it almost the passion of his life to see that come about, he wished to utter the strongest protest he could against the development being attempted by Governments. He saw with dismay the association of the Australian Government with the British Government for the purpose of developing oil in Papua and New Guinea. Hundreds of thousands of pounds had been spent, and no results obtained. He was thoroughly persuaded that the future of the British Empire depended on the efforts and ability of individuals, and he hoped everyone in that room would protest if they got the chance—and the chance came at the polling-booth—in the hope of dissuading the Government from entering into any such trade, especially a trade which had the immense risks of oil, and which would bring them into competition with all other companies and nationalities, involving sometimes, as had been seen, the most grave political troubles. An instance of the kind arose in Egypt, and in that connexion he was glad to see Sir Henry McMahon, Government director of the Anglo-Egyptian oilfields, there that afternoon. The Egyptian oilfields were developed by British enterprise. They had been attempted by the Americans, and the only effect was that the Americans left the field water-logged, and it had not been possible to get it right yet, and he was afraid it would never be. Incidentally he would like to say that Sarawak was very fortunate in that the Government and the company worked hand-in-hand without the slightest fear of friction, because the remuneration of the Government was by means of royalties. He could not imagine anything more unfortunate than the participation of Governments deriving their royalties from profits. That was a fruitful source of trouble. But to return to Egypt. Thanks to the prescience of Lord Kitchener, the Government took an interest in this case. Lord Kitchener laid it down at a time when there was no production there, and when it was doubtful whether there would be profits or not, that the Egyptians had to be considered and that regard must be had to the future. That was quite right, but he (Lord Bearsted) did not think anybody ever contemplated that when success was attained the Egyptian Government should go into business themselves in opposition to the Company in which they had got an interest. The result had been very extraordinary indeed. The Government had attained no success whatever, but they had spent, he should think, at least half a million in trying for it, and it only showed again that these ventures were much better left to private enterprise, because individual Directors who were responsible for the public money were much more likely to exercise care than the Government. He sincerely hoped and firmly believed that in Sarawak, as elsewhere, it would be proved again that trade invariably followed the production of oil, and that Sarawak would not only be a great centre for oil, but that the trade done there in the future would eclipse anything that the noble and enterprising founder of the Colony ever foresaw.

LT.-COL. SIR PERCY CUNYNGHAME, Bt., O.B.E., said that he was afraid he could not tell the meeting very much about the progress of Sarawak as it was to-day, because he left it in 1909, and at that time he thought the Company had only just obtained their concession. The country had not then the great advantage of the genius and foresight of Lord Bearsted and those who were assisting him in its development, but they had nevertheless, a certain amount of European capital. They had the gold mines, which for a long time yielded a high profit. These had now been closed down. It was a country, however, which was potentially very rich, and, of course, as they knew, after hearing the lecture and also the most illuminating address which Lord Bearsted had given, immense possibilities awaited its development. When he was in Sarawak he was in the service of the late Rajah, Sir Charles Brooke, a man for whose memory he had a great esteem. He was a man who regarded his country and his people as a sacred trust, and when

he came to consider any question connected with Sarawak, the Rajah always asked himself first the question whether this would be to the advantage of the country itself and of its people. Of course his actions were criticised, and supposed to be too conservative. People said that if European capital had been allowed to operate earlier the development of the country might have been quicker. But the answer to that was that when the present Rajah came into this inheritance, on the death of his father, he found a country which was unencumbered with debt, whose taxation was light, and whose population was loyal and absolutely devoted to the Brooke regime. They were fortunate to-day in the inhabitants they had in Sarawak. The generally-accepted idea of the Malay was that he was rather a treacherous and bloodthirsty individual. Personally the speaker had never found him so, but, on the contrary, a very lovable person, who was capable of showing loyalty and devotion to the European whom he knew and trusted. The Malays had thoroughly proved their loyalty to the British Rajah. In the days of the Chinese insurrection, when the Rajah was himself a fugitive, and had to throw himself on the protection of this subject race, the Malays rallied round him and protected him until such time as a force could be got together which could drive the Chinese out of the country. This was the more remarkable because the Chinese insurrection was not directed against the Malays at all, but against the whites. The action of the Malays was a proof of what could be done when natives trusted and liked Europeans. He thanked the lecturer and Lord Bearsted for what they had said. To him it had been most interesting, because it had enabled him to follow the progress of the country in a way that he had never been able to do in reading about it in pamphlets and books.

Sir Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I., said that they would all agree that the Society had been given a most interesting description of the birth and growth of Sarawak. Nowadays they heard so much about oil that anything connected with its production must be of interest. But the Sarawak field that they had heard of that evening was a very much more important one than might be assumed from its actual size. As the Chairman had said, it owed its importance to its geographical position. Oil was now becoming the predominant motive power of the world, and this was especially the case at sea. The geographical position of oil-fields in relation to trade routes was becoming a more and more important question. Lord Bearsted had referred to his own connexion with the Anglo-Egyptian oil-fields. Egypt during the war was called—the Clapham Junction of the world. It was very fortunate that just alongside that Clapham Junction of sea-borne traffic there was a very useful and productive oil-field, which was worked at great pressure to meet the necessities of the War, and produced about 5,000 tons a week. That was at a moment when ships were not obtainable, and it was a very difficult matter to convey oil to Egypt. That supply of 5,000 tons a week came in very useful indeed, not only to industry, but to the British Government. There was now another Clapham Junction of equal importance in the world, some people would say of even more importance. This Clapham Junction was the Malay States and Singapore, and they had been hearing that evening of a conveniently-situated oil-field, not very far from that strategic centre. It was a very fortunate thing to find oil-fields under British control close to these great junctions. Yet, after all, it was not entirely a matter of fortune. It was the result of shrewd and far-reaching vision and of bold enterprise, and he would let the Society into a secret. They were indebted for that vision and that enterprise to Lord Bearsted, the Chairman of that meeting.

Mr. Byron Brenan, C.M.G. (late Consul-General for Shanghai), proposed a vote of thanks to the reader of the paper, and to Lord Bearsted for taking the Chair. He was sure the Society had heard the lecture, not only with interest, but with pleasure, because the lecturer had invested an uninteresting subject like the production of oil with a certain atmosphere of romance. They all liked to know whence came the products which many of them used, and all of them used oil in different ways. Some used it for motor cars, others for lamps, others again in humble ways to stimulate the growth of hair or to remove grease spots from waistcoats! But they were all interested in the subject. He thought that the author of the paper might be a thorn in the side of the Chancellor of the Exchequer if he drew any of them away to that happy land where they escaped income tax. They were much indebted to Lord Bearsted for sparing his valuable time to come there that day. In anything connected with petroleum his name was a household word. He had given them a hint what to do with their surplus goods, namely, to put them back into the earth, and he imagined that he had got the idea from watching the squirrels in Regent's Park!

The resolution was carried unanimously.

Mr. Cochrane said that he was instructed by Lord Bearsted to reply on his Lordship's behalf as well as his own. As far as he himself was concerned it had been a great pleasure to endeavour, however inadequately, to give some idea of the present position of the Sarawak oilfields, and any who had found his paper dull had at any rate had the advantage of hearing a speech from Lord Bearsted in which he had dealt with a number of other places besides Sarawak, which were perhaps of more general interest to the audience.

He wished to thank Mr. Brenan and the audience on behalf of Lord Bearsted and of himself for the

very kind way in which the vote of thanks had been proposed and accorded.

MR. H. WYNDHAM JONES writes:—

In the early part of his paper Mr. Cochrane mentions that Sarawak Government officials reported the coast near Miri to be unapproachable from September to March, viz.—the North-east Monsoon season.

Later, he states that during 1923 no less than 530,000 tons of petroleum were shipped from Miri in 115 tank vessels, which means an average of 1,450 tons a day or a tank vessel every three days or so.

This shipment of petroleum is not effected only during the favourable monsoon season, but must of necessity be carried out throughout the year. In addition, it is necessary to ship to Miri in the course of the year, several thousands of tons of drilling material, casings, pipe lines, machinery and general supplies. These shipments also must be made continuously throughout the year, but are seldom made on tank vessels, for various reasons.

Those of the audience who are acquainted with the Indian Ocean and China Seas will know that the fury of the monsoons has not abated. The Port of Miri is still an open roadstead with but a slightly curved beach-line, and entirely exposed to weather coming from the west, the north and the greater portion of the north-east quadrant. Mr. Cochrane has mentioned that the bar at the mouth of the small Miri River carries only one foot of water at low water spring tides. It happens also that "tides" at Miri are peculiar in so far that in general there is but one high tide during each 24 hours, although during "slack" or neap tide periods a slight supplementary tide is sometimes noticed; under these conditions all incoming cargoes have to be handled.

The foregoing observations are intended to emphasise the difficult conditions which have to be faced at Miri and the high grade of efficiency that is organised and maintained to cope with the shipping side of the business.

OBITUARY.

WILLIAM HENRY MAW, LL.D., M.INST.C.E.—Dr. William Henry Maw died after a very brief illness at his residence in Addison Road, Kensington, on March 19th, at the age of 85. He will be greatly missed at the Royal Society of Arts, where he was a regular attendant at meetings of the Council and of the Finance Committee. He joined the Society in 1890. In 1911 he was elected a member of the Council, on which he served until 1914, and again from 1917 onwards. In 1919 he was appointed one of the Society's Treasurers, an office which he held up to the time of his death.

Dr. Maw was born at Scarborough in 1838. After spending ten years in the works of the Great Eastern Railway at Stratford, in 1866 he joined the staff of *Engineering*, of which he continued to be a joint editor all the remainder of his life. In addition to this work he practised as a consulting engineer, and he took a keen interest in the work of various technical institutions. He was President of the Institution of Mechanical Engineers in 1901-2, and of the Institution of Civil Engineers in 1922-23. He assisted in the formation of the Engineering Standards Committee in 1901, and he was a member of the Royal Commission for the St. Louis Exhibition in 1904. During the war he served on the Advisory Panel of the Munitions Inventions Department of the Ministry of Munitions.

Dr. Maw was a very keen astronomer and microscopist. He was at one time president of the Royal Astronomical Society and of the British Astronomical Association. He was the author of a paper on "Double Star Observations," and of a book on "Recent Practice in Marine Engineering," and was joint author of "The Waterworks of London" and "Road and Railway Bridges." He received the honorary degree of LL.D. from the University of Glasgow in 1909, and last year the Iron and Steel Institute awarded him the Bessemer medal.

NEW INDUSTRIES FOR MALAYA.

Extensive experiments in the cultivation of crops other than rubber and coconut are being conducted by the Department of Agriculture of the Federated Malay States and the Straits Settlements, writes the United States Consul General in Singapore. The object is to determine what crops, especially those of quick maturity, are most suited to native production. The step is indicative of the increasing interest throughout Malaya in the development of more diversified production as a result of the recent rubber and tin depressions and the consequent restriction in export acreage.

An area of 450 acres on a new plantation at Serdang has been cleared for the purpose and divided into regular blocks for the planting of various crops. Careful records are to be kept and experiments on short-duration crops will be repeated until definite data are obtained. At the present time there are over 100 different species of plants on the plantation and a large number of different varieties of the same species in a number of cases. The principal crops included in the plan with the approximate area allotted to each, are the following: African oil palm, 50 acres; limes, 50 acres; sugar, including 23 varieties of Malayan and Javanese canes, 25 acres; kapok, 50 acres; sisal hemp, 25 acres; Mauritius hemp, 25 acres; manila hemp, 4½ acres; roselle fibre, 3 acres; coffee, including robusta and five different Javanese varieties, 10 acres; croton oil, 9 acres; candle nut, 8 acres; cocaine, 5 acres; papaya, 2 acres; and bananas, 437 numbered lots comprising approximately 125 varieties collected from various sections of the Malay Peninsula. The nurseries are well stocked with material for planting to carry out the present programme.

THE EGG TRADE OF EGYPT.

According to reliable unofficial estimates, writes the United States Consul at Alexandria, the production of eggs in Egypt is approximately 150,000 cases per annum, each case containing 1440 eggs. About 70 per cent. of this production is exported.

For commercial purposes Egyptian eggs are divided into three classes. Fayoum eggs, produced in the fertile province of Fayoum, south-west of Cairo, constitute the first class. Because of their relatively large size they sell at higher prices than any other eggs. Beheri, or Delta, eggs, produced in the triangular area between the two branches of the Nile below Cairo, constitute the second class. The third and lowest-priced class consists of Saidi, or Upper Egypt, eggs.

The principal purchaser of Egyptian eggs is the United Kingdom, which takes more than 90 per cent. of Egypt's total exports of this commodity. The following table, compiled from official Egyptian customs statistics, shows the quantity, value, and destination of eggs exported from Egypt in 1921 and 1922:—

Destination.	1921 Number in thousands.	1921 Value.	1922 Number in thousands.	1922 Value.
		LE		LE
United Kingdom	87,960	326,316	156,907	503,979
British Mediterranean possessions	229	890	72	194
France	1,699	5,803	2,881	9,378
Palestine	322	1,133	80	272
Spain	1,194	4,168	39	136
Syria	50	218	...	...
Turkey	72	288	82	287
Other countries	275	963	191	531
Total	91,801	339,770	160,252	514,777

LE=£1 0s. 6½d.

Active shipments of eggs from Egypt begin in November and continue until July. Maximum shipments occur from January to April. Eggs are usually shipped by Alexandria produce exporters either on consignment or to agents on a commission basis.

COTTON GROWING IN AUSTRALIA.

An article dealing with the present position of cotton-growing in Australia and the possibility of the Dominion becoming an important source of supply, is published in the current issue of the "Bulletin of the Imperial Institute." The author, Mr. W. H. Johnson, who was at one time Director of Agriculture in the Southern Provinces, Nigeria, recently paid a visit to Australia to report on the suitability of different parts of the country for cotton cultivation.

In 1788, Governor Philip brought cotton seed from South America to plant in Sydney, and since then many attempts have been made to grow cotton in Australia. The first bale of cotton exported from the Dominion was produced in Queensland in 1852. With the help of premiums paid by the Government and the high prices ruling as a result of the American Civil War, production increased and, in 1871, shipments from Queensland amounted to 2,602,100 lbs. Subsequently, the industry declined, and, with the exception of a slight revival in 1890, remained practically dormant until the last few years. Considerable interest has now been again aroused. The Queensland Government are encouraging the growth of the industry by providing cotton seed free of charge for planting purposes, and by paying farmers a guaranteed price for seed-cotton; assistance is also being rendered by the British Cotton Growing Association. In 1922, an area of 7,000 acres was planted with cotton in Queensland and the yield of seed-cotton by the end of August had amounted to over 3½ million lbs. Mr. Johnson discusses the problems confronting the planter in the various regions where cotton growing has been proposed, and concludes that the soil and climatic conditions in large portions of Queensland, Northern New South Wales, North-West Australia, and in the Irrigation Settlements of Victoria, New South Wales, and South Australia, are well adapted for cotton cultivation, but carefully conducted trials will be necessary to decide whether the crop can be grown profitably on a large commercial scale.

WATER POWER RESOURCES OF THE DUTCH EAST INDIES.

In his recent report on the Economic Situation of the Netherlands East Indies, the British Commercial Agent at Batavia states that the total water power available in the Netherlands East Indies amounts to 5,500,000 h.p. divided amongst the various islands, of which Java possesses 500,000, Sumatra 2,000,000, Borneo 2,000,000, and Celebes 1,000,000 h.p. Of this total only 60,000 to 70,000 h.p. has up to the present been exploited.

In the above schedule New Giunea has not been included; the power exploitable in this island alone amounts to 5,000,000 h.p.

The harnessing of water power and the erection of electric generating plants are stimulated in Java by the abundance of cheap labour available, and by the plentiful supply of building materials which may be obtained locally. Nearly all concessions granted are for medium and high falls, that is to say from 50 to 200 metres. The two types of water turbines which are at present exclusively used are the Pelton wheel and the Francis turbine. With very few exceptions, all installations now being erected are of Swiss or German origin.

No attempt has yet been made to harness low falls of water, owing to the large initial capital outlay entailed thereby, although the water supply available at the Asahan, Ombilin and other rivers in Sumatra, which would necessarily be low falls, have been completely surveyed, and will no doubt be developed as soon as money is more plentiful, and the large capital required can be found.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at 8 o'clock :—

APRIL 2.—SIR LYNDEN MACASSEY, K.B.E., "London Traffic." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

APRIL 4 (Monday at 4.30 p.m.). -GEORGE MACAULAY BOOTH, Director of the Bank of England and of the Booth Steamship Co., Ltd., "The Amazon Valley and Its Development." H. E. THE BRAZILIAN AMBASSADOR will preside.

APRIL 9.—FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum." PROFESSOR C. VERNON BOYS, F.R.S., will preside.

APRIL 30.—BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "The London Dock District and its Roads."

MAY 5 (Monday).—T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MAY 7.—J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation." ADMIRAL OF THE FLEET SIR HENRY JACKSON, G.C.B., K.C.V.O., F.R.S., will preside.

MAY 14.—

MAY 21.—PROFESSOR C. VERNON BOYS, F.R.S., "Calorimetry." (Trueman Wood Lecture.)

MAY 28.—MRS. ARTHUR McGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock :—

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced :—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

TUESDAY, MAY 27, at 4.30 o'clock.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

WEDNESDAY, JUNE 4, at 4.30 o'clock.—THE RT. HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates."

MONDAY, JUNE 16, at 4.30 o'clock.—C. V. CORLESS, M.Sc., LL.D., "The Mineral Resources of Canada: The Pre-Cambrian Area."

COBB LECTURES.

Monday evenings, at 8 o'clock :—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

SYLLABUS.

LECTURE II: MARCH 31.—Hardening of gelatin. Ordinary fixing and acid fixing baths.

Medium free silver halide. Gelatine as a retarder of development. Black and grey silver images. Coloured silver images and silver colour scale. Production of coloured images Gelatine as a sensitiser.

Lecture III: April 1.—Photohalides and the visible image. Sensitising action of silver ions. Latent image. Duplication of light action by chemical agents. Silver halide grain as the unit. Sensitive centres on the grains. Nucleus exposure. Nature of the sensitive centres.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, March 31 Farmers' Club, at the Surveyors' Institution, Great George Street, S.W., 4 p.m. Mr. J. Wyllie, "How to adapt the Methods of Farming to the changed conditions of Agriculture."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. H. S. Goodhart-Rendel, "English Gothic Architecture of the 19th Century."

Electrical Engineers, Institution of, Victoria Embankment, W.C., 7 p.m. (Informal meeting). Mr. F. Gill, "Economics in Engineering."

Society of Chemical Industry and Institute of Chemistry. Joint Meeting, at Institution of Mechanical Engineers, Storey's Gate, S.W., 8 p.m. Films of "Coal and its Products," and "Heavy Chemicals."

Actuaries, Institute of, Staple Inn Hall, Holborn, W.C., 5 p.m. Discussion on "The Inclusion of Disability and Fatal Accident Benefits in Life Assurance Contracts."

Tuesday, April 1 Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. G. Gordon, "Ballads." (Lecture II.)

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. (1) Mr. D. H. Remfry, "The Interaction in Bridgework of the Deck System on the Main Girders, and the consequent modification of stresses therein." (2) Prof. C. E. Inglis, "Theory of Transverse Oscillations in Girders and its relation to live-load and impact allowances."

Alpine Club, 23, Savile Row, W., 8.30 p.m. Mr. R. A. Frazer, "A Plea for Mountaineering in Central Spitzbergen."

Photographic Society, 35, Russell Square, W.C., 7 p.m. "The Making of a Topical Film."

Zoological Society, Regent's Park, N.W., 5.30 p.m. (1) Mr. O. Thomas, and other European Mamalogists, *Nomina Conservanda* in Mammalia. (2) Dr. W. N. F. Woodland, "On a new Species of Cestode of the Genus *Caryophyllæus*, from an Egyptian Siluroid. (3) Dr. C. H. Joh. Petersen, "The Necessity for Quantitative Methods in the Investigation of Animal Life on the Sea Bottom." (4) Prof. R. T. Leiper, "An Account of the Parasitological Work at the Society's Gardens."

Wednesday, April 2 London County Council, at the Royal Society of Arts, John Street, Adelphi, W.C., 6 p.m. Sir Napier Shaw, "Modern Meteorology." (Lecture VI.)

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. (Wireless Section). Messrs. M. Thompson and A. C. Bartlett, "Thermionic Valves with Dull-Emitting Filaments."

British Decorators, Institute of, Painters' Hall, Little Trinity Lane, E.C., 3 p.m. Annual General meeting.

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. (Students' meeting). Engineer-Captain J. A. Richards, "The Manufacture of Solid-Drawn Steel Tubes."

Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. (1) Mr. J. Golding, Report on The World's Dairy Congress held at Washington, D.C., U.S.A. (2) Messrs. L. H. Lampitt, E. B. Hughes, and M. Bogod, "The Routine Examination of Dairy Products with special reference to the Mojonnier Tester." (3) Dr. J. C. Drummond, Miss M. G. Palmer, and Miss D. E. Wright, "Experiments on the Absorption of Copper following the Consumption of Vegetables containing Copper Sulphate." (4) Messrs. J. H. Lane and L. Eynon, "Determination of Sugar in Urine by means of Fehling's Solution with Methylene Blue as Internal Indicator." (5) Miss P. H. Price, "Attempt to extend Mitchell's Colorimetric Method to the Catechol Tannins."

Thursday, April 3 Aeronautical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Colonel the Master of Sempill, "The British Aviation Mission to the Imperial Japanese Navy."

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W.

Linnean Society, Burlington House, Piccadilly, W., 5 p.m. (1) Mr. C. Turner, "Further notes on the development of *Staurastrum Dickiei var parallelum nordst.*" (2) Dr. H. S. Holden, "On tyloses and cavity parenchyma in Ferns." (3) Dr. H. S. Holden and A. Evelyn Chesters, "On the seedling anatomy of certain species of *Lupinus*." (4) Mr. W. O. Howarth, "Occurrence and distribution of *Festuca ovina* in Britain."

Chemical Society, Burlington House, Piccadilly, W., 8 p.m. (1) Mr. E. H. Ingold, "The Tautomerism of Dyads. -Part II. Acetylene and its Halogen Derivatives." (2) Messrs. H. Bassett and D. J. T. Bagnall, "The Potassium Salts of Phenolphthaloin." (3a) Messrs. H. Bassett and A. S. Corbot, "A Phase Rule Study of the Cupro-, Argento-, Auro-, and Thallo-Cyanides of Potassium." (3b) "The Hydrolysis of Potassium Ferricyanide and Potassium Colbaticyanide by Sulphuric Acid."

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Dr. J. E. Borland, "Music in the Schools."

Mechanical Engineers, Institution of, (Local Section). Royal Technical College, Glasgow, 7.30 p.m. Mr. D. Fife, Boiler Construction and Maintenance.

Royal Institution, Albemarle Street, W., 5.15 p.m. Dr E. J. Allen, "Scientific Research on Sea Fisheries." (Lecture I.)

Friday, April 4 Royal Institution, Albemarle Street, W., 9 p.m. Prof. Sir E. Rutherford, "The Nucleus of the Atom."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, (Informal meeting), 7 p.m. Discussion on "Mechanical Methods of Boiler Firing."

(Yorkshire Section), Philosophical Hall, Park Row, Leeds, 7.30 p.m. Mr. F. Darley, "Design and Manufacture of Steel Castings."

Engineers, Junior Institution of, 39, Victoria Street, S.W., 7.30 p.m. Mr. A. J. Sear, "Mineral Oils, with special reference to Lubricating and Inculating Oils."

Geologists' Association, University College, Gower Street, W.C., 7.30 p.m.

Philological Society, University College, Gower Street, W.C., 5.30 p.m. Prof. W. A. Craigie, "Dictionary Evening."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Messrs. A. C. Banfield and B. Cox, "The Oil Processes." (Demonstration.)

Saturday, April 5 .. Royal Institution, Albemarle Street, W., 3 p.m. Dr. C. Singer, "Aristotle as a Biologist."

Journal of the Royal Society of Arts

No. 3,724. VOL. LXXII.

FRIDAY, APRIL 4, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

MONDAY, APRIL 7th, at 8 p.m. (Cobb Lecture.) DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." (Lecture III.)

WEDNESDAY, APRIL 9th, at 8 p.m. (Ordinary Meeting.) FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum." PROFESSOR C. VERNON BOYS, F.R.S., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

SIXTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 26th, 1924; PROFESSOR E. W. MACBRIDE, D.Sc., F.R.S., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Eedy, Arthur Malcolm, Sydney, Australia.
Muir, James, London.
Rothfeld, Otto, I.C.S., London.

The following candidates were duly elected Fellows of the Society:—

Campbell, Andrew, Beckenham, Kent.
Sharp, Mrs. Katharine Dooris, London, Ohio, U.S.A.
Williams, Professor Clement Clarence, Urbana, Illinois, U.S.A.

A paper on "The Fishing Industry and its By-Products" was read by MR. NEAL GREEN.

The paper and discussion will be published in a subsequent issue of the *Journal.*

COBB LECTURE.

MONDAY EVENING, MARCH 31st, 1924; DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, delivered the second lecture of his course on "Certain Fundamental Problems in Photography."

The lectures will be published in the *Journal* during the summer recess.

VISIT TO THE GUILDHALL.

On behalf of the Fellows of the Society and their ladies, the Council have gratefully accepted an invitation from Mr. H. G. Downer, LL.B., a member of the Common Council, to inspect the Guildhall, including the Art Gallery of the Corporation of London, on Thursday, May 8th, at 2.30 p.m.

Sir Alfred George Temple, F.S.A., will act as escort in the Art Gallery and Mr. Deputy Alderton, C.C., in the Council Chamber, Crypt and other places of interest in the Guildhall.

Fellows desirous of availing themselves of the invitation should inform the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.2, on or before May 3rd, mentioning the number of their party.

Those attending are requested to assemble at the main entrance to the Guildhall in King Street, Cheapside, at 2.30 p.m.

PROCEEDINGS OF THE SOCIETY.

EIGHTH ORDINARY MEETING.

WEDNESDAY, JANUARY 30TH, 1924.

SIR HERBERT JACKSON, K.B.E., F.R.S., in the Chair.

The following paper was read:—

THE HISTORY, DEVELOPMENT AND COMMERCIAL USES OF FUSED SILICA.

By SIR RICHARD ARTHUR SURTEES PAGET, Bt.

Silica is the commonest constituent of the earth's crust. It is estimated that of the first 10 miles' depth, 60% consists of silica (SiO_2)—occurring as quartz rock, sandstone and other forms of SiO_2—either free, or combined with metals or metallic compounds in the form of silicates, or the like. The "full dress" form of pure silica is rock crystal, from which all the highest grades of transparent fused silica are made. Deposits

FIG. 1.—Photograph of Exhibits (transparent and heavy chemical ware, etc.)

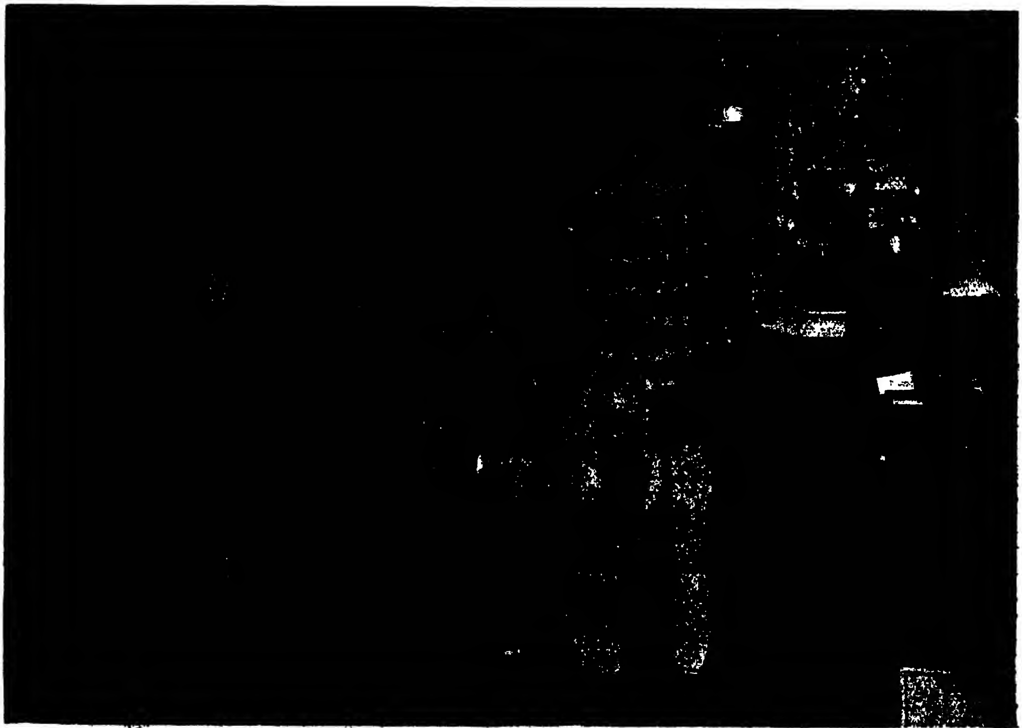

FIG. 2.—Photograph of Exhibits ("Ostrich Egg," big flask, Brussels Exhibition fire exhibit, etc.)

of large crystals are of comparatively rare occurrence. Next, in order of utility for our purpose, may be placed the deposits in the form of small crystals of rock crystal, which occur in Germany, Sweden and elsewhere and are commercially known as geyserite. True geyserite is a semi-hydrated silica of the opal type, deposited by water containing dissolved SiO_2. Lastly there is silica sand—the principal raw material of the glass-maker—which, in varying degrees of purity is found throughout the world. For the manufacture of fused silica ware only the highest grades are suitable, *i.e.*, with a silica content of about 99.8.% No such deposits are known in this country and all sand for fusion is at present imported from France.

Silica also occasionally occurs in other crystalline forms, namely, as Tridymite (in certain volcanic rocks) and more rarely as Crystobalite. These forms are of no importance as sources of silica, but are very material (as we shall see later) in connection with the behaviour of fused silica under heat treatment.

Natural fused silica—fused by the earth's internal heat—occurs in certain volcanic rocks. The earliest experiments in silica fusion on the earth's surface were made by Nature herself and consisted in passing a very high tension static discharge (in other words, a flash of lightning) through a bed of silica sand.

The result is a rough tube of fused silica usually of ¼″ to ½″ diameter, glassy on the inside, but with an unfused sandy exterior. These tubes—known as Fulgurites or Le chatelierite — have been discovered in lengths up to 37ft. at Drigg in Cumberland. The present small samples come from Maldonado in Uruguay and from Griqualand in South Africa. Fulgurites were first observed in 1711 by Pastor L. D. Hermann at Massel in Silesia and were attributed to lightning, in 1805, by Dr. Hentzen in Westphalia. The Drigg specimen is described by E. L. Irton, Trans.: Geolog. Soc., 1814, Vol 2, p. 528. Darwin refers to the Uruguayan fulgurites in his geological observations (Voyage of H.M.S. "Beagle.").

In 1839 Gaudin of Paris, communicated to the Academy of Science his experiments on quartz (*i.e.* silica) fusion. Gaudin used the oxyhydrogen blowpipe; he found (1) that fused quartz never became truly fluid; (2) that it began to volatilise near its melting point; (3) that on cooling it became a transparent glassy mass; (4) that in this condition the material was unaffected by sudden changes of temperature, and showed remarkable strength and elasticity; (5) that on prolonged heating the vitreous quartz returned to the crystalline condition, *i.e.*, it became devitrified, and lost its mechanical strength. If nature herself is the mother of fused silica, Gaudin may fairly claim to be its father.

In 1878 Gautier exhibited small fused quartz tubes made in the blowpipe.

In 1887 Vernon Boys devised his beautiful method of drawing very fine quartz threads by means of a miniature crossbow and arrow. (Fig. 3.) The flight of the arrow was made to draw out a thin rod of fused quartz

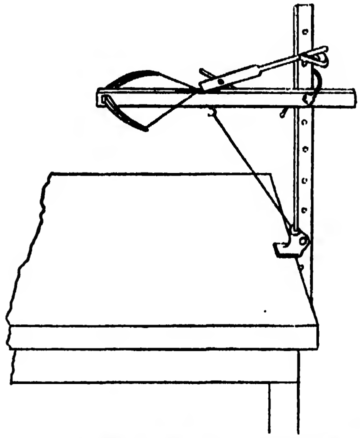

FIG. 3.—General arrangement of Boys's apparatus for making quartz fibre.

heated in the blowpipe, and threads up to 30ft. in length were produced in this way.

In 1888 Sir Charles Parsons communicated to the Royal Society a series of experiments, including that of fusing silica sand by means of an electrically heated carbon rod embedded in the sand—the fusion being carried out inside a closed cylinder and under a pressure of five to thirty tons per sq. inch. This is, I believe, the first instance in the history of silica fusion of the use of a carbon resistance rod, which has since become the standard system of heating.

Threlfall's "Laboratory Arts" (Macmillan 1898) describes the preparation of quartz fibres and the manufacture of insulators, etc. In 1899 Threlfall, at Oldbury, fused quartz in quantity in a 100 k.w. arc furnace, but did not succeed in working it.

In 1900 Schott and Genossen exhibited a fused quartz lens at the Paris Exhibition.

In 1901 Shenstone demonstrated at the Royal Institution his method of building

up fused silica tubes by drawing pieces of rock crystal out into thin rods in the O-H blowpipe, assembling these faggot-wise round a platinum core and then fusing them together in the blowpipe.

In 1903 Heræus, in Germany, exhibited apparatus of fused quartz, made, I believe, by dropping rock crystal (previously heated above 600° C.) into an iridium tube furnace heated internally by oxyhydrogen flames, and working the product in the blowpipe.

Shenstone's method was developed commercially by Messrs. Johnson and Matthey, their organisation for this purpose being known as the Silica Syndicate. This company made notable improvements in the manufacture of transparent fusions. Kent's method of building up a bubble free fusion (Fig. 4)

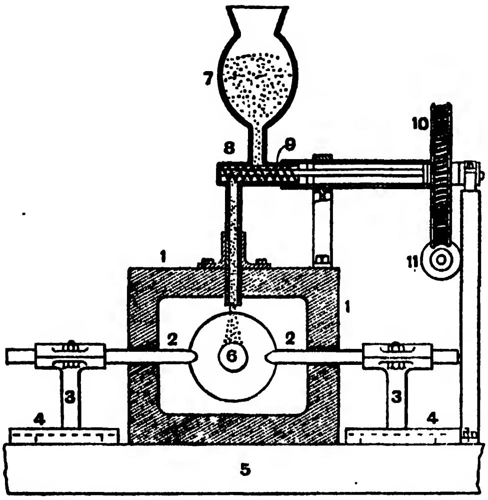

FIG. 4.—Apparatus illustrating Kent's process of manufacturing transparent fused quartz as rod or tube.

consisted in feeding rock crystal powder into the heated zone. The mass thus formed was subsequently worked in the O.H. blowpipe. (See Exhibits 1 in Fig. 1).

Heræus's process was developed by his firm, W. C. Heræus, of Hanau, which has continued to develop the use of transparent silica apparatus.

All these processes (except Sir Charles Parsons's) used rock crystal and produced a transparent glass-like product—more or less free from bubbles.

Complete freedom from bubbles is extremely difficult to attain owing to the fusion never becoming liquid. Subsequent research by Day and Shepherd showed that silica does not become liquid even when superheated at a pressure of 35 atmospheres.

Numerous proposals have been made to eliminate bubbles by fusing silica in vacuo, with or without a subsequent compression of the plastic fusion.

Thus, in 1904 and 5, Bredel, in Germany, patented a process of fusing in vacuo and allowing the fused mass to flow into an evacuated mold, or of fusing *from below* in an evacuated furnace.

In 1906 Wingrens, of Pasadena, Cal., patented a process of fusing in vacuo, and then subjecting the plastic fusion to gaseous pressure.

In the same year Day & Shepherd, of the Carnegie Institution, Washington, described the production of transparent silica plates by fusing rock crystal in an electrically-heated graphite box at 2,000° C., followed by further heating at 1,800° C, under a gaseous pressure of 500 lbs.

In 1907, Ludwig Bolle, in Germany, patented a process of silica fusion in a tubular furnace, the fusion being extruded by mechanical or gaseous pressure.

We now come to the fusion—on a larger scale—of pure silica sand. The inherent difficulty lies in the fact that, at the temperature of fusion, silica reacts with practically every known refractory material, except the refractory metals—platinum, iridium, etc., the cost of which is prohibitive, except for small scale operations.

In 1902 two important steps were taken. In the U.S.A. Elihu Thomson patented a method of forming articles of fused silica by a process similar to that of Sir C. Parsons, but working at atmospheric pressure. Thomson's heating core (Fig. 5) was of carbon or graphite and was so shaped as to form the mold or core for the ultimate product, *i.e.*, fusion round a rod produced a tube of silica—a basin-shaped heating core produced (or was intended to produce) a silica basin. The carbon core, surrounded by the sand to be fused, was electrically heated (the electrical data were not disclosed in the patents) until the sand in contact with the core was melted to the required thickness. The current was cut off, the fusion allowed to cool, and the fused mass mechanically separated from the cold core, or the core was burnt off by excess of oxygen.

In this country R. S. Hutton, of Owen's College, Manchester, who had previously worked with Moissan in France on the arc furnace, independently developed a very similar process.

Hutton formed silica tubes either by

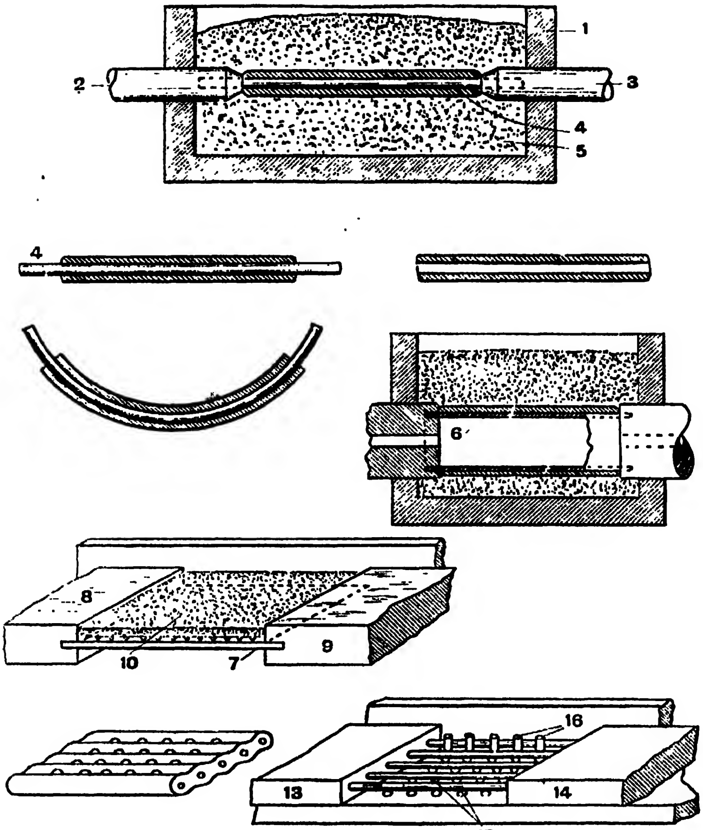

FIG. 5.—Elihu Thomson's process for manufacturing tubes, etc.

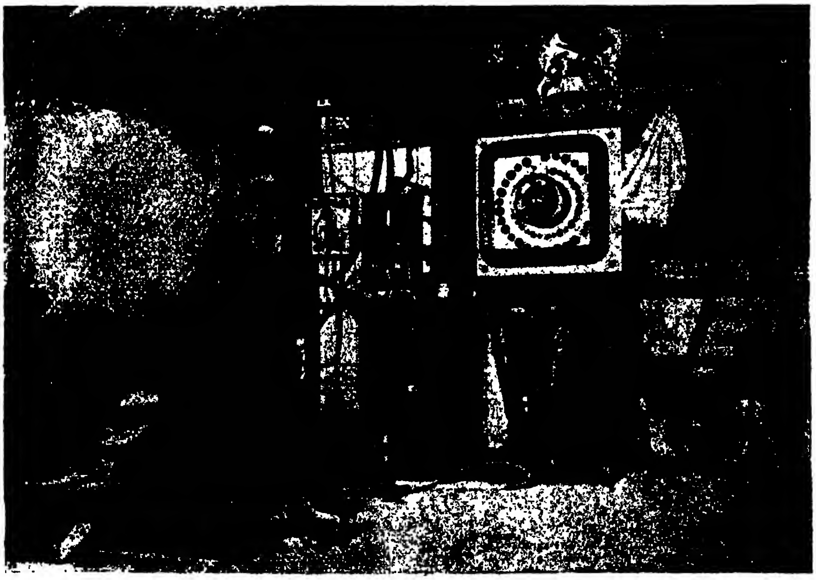

FIG. 6.—Furnace used by Dr. Bottomley in his early experiments.

passing a current through a carbon rod embedded in sand, or by supporting sand in a graphite trough having a graphite core fixed axially within it, and fusing the sand round the core by an ele.tric arc arranged to travel longitudinally immediately above the trough. Threlfall, using Hutton's first method, made rough tubes up to 5″ and 6″ in diameter and (in one instance) up to 12 to 15 feet in length.

All these methods produce the same *new* material, namely, a fused silica of white slightly translucent appearance, like compressed snow, the colour and opacity being due to the large numbers of small air or gas bubbles disseminated throughout the mass. Both processes suffered from the disadvantage that the size and shape of the fusion were limited to those of the heating core, and that owing to the liability of silica to react with carbon—forming carborundum with evolution of carbon monoxide gas—the separation of the carbon core and production of a clean fusion were matters of much difficulty and uncertainty. A similar process to those of Thomson and Hutton was patented in Germany by Ruhsetradt in the same year. In all these processes it was essential to keep the temperature *as low as possible*, to avoid the reaction of silica and carbon.

About 1902 the present Lord Rayleigh (who is now, I am glad to say, associated with the Thermal Syndicate) showed me a small tube of fused silica, which he had made for some experiments on the critical temperature of mercury, and he described the interesting properties of the material.

As the result experiments were started at Wallsend, in 1903, with the object of developing, if possible, a commercial method of fusion by means of some form of electric furnace. The late Dr. J. Frank Bottomley was in charge of the experiments, with Mr. R. W. Clark as his electrical assistant. Messrs Merz and McLellan designed the electrical equipment, Mr. R. S. Hutton acted as consultant, and the present lecturer, so to speak, "also ran." After numerous failures, with both arc and resistance heating, an accidental result pointed the road to success.

The furnace (so to call it) consisted of a built-up brick or metal trough full of sand with a heating core fixed axially within it. (Fig. 6). Dr. Bottomley's note of the experiment explains what occurred:—

Fusion of sand with a rod of graphite as core.

The previous experiment was repeated with the difference that the core was composed of a single graphite rod between two 3″ carbons.

The current readings during the experiment were the following:—

start	9.50	1160 amps.	14 volts.
	10.3	1175	14
	10.20	1200	14
	10.30	1400	16 current increased.
	10.33	1420	16
	10.48	700	40
	10.49	860	52
	10.51	current broken.	

After 49 minutes heating the gas given off by the reaction between the quartz and silica burst through, and shortly afterwards the rod broke.

On opening up the furnace it was found that the fused sand has been blown out by the pressure of gas generated to a large egg shaped mass. The sand was well fused for about an ⅛″. The size of the piece was about 13″ long by 7″ diameter.

Here are the actual fusions produced by these experiments. (See Exhibit 1 of Fig. 2).

It soon became clear that by working at a much higher temperature than Thomson and Hutton, and by carefully regulating the temperature, it was possible not merely to bring the whole fusion to a state of substantially uniform plasticity, but also so to regulate the interior gaseous pressure (due to CO and silica vapour formation) that the fusion *remained separated from the core* except at the relatively cool extremities of the core. Under these conditions there was no further reaction between silica and carbon, and the fusion could be blown up in situ into molds surrounding the fusion.

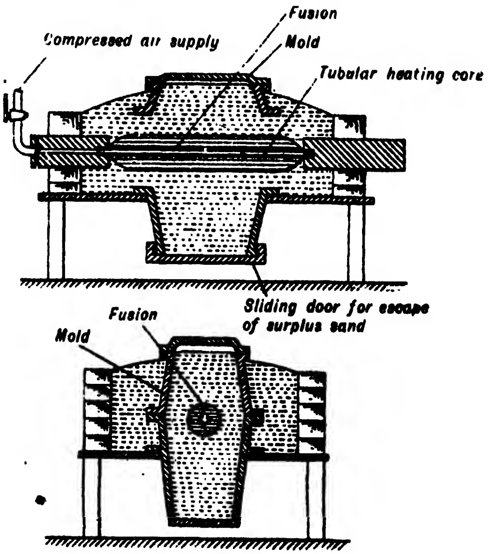

Fig. 7.

(Fig. 7). A little later it was found that the core could be withdrawn altogether from the fusion and the fusion itself removed from the furnace. (Fig. 8). Moreover, the

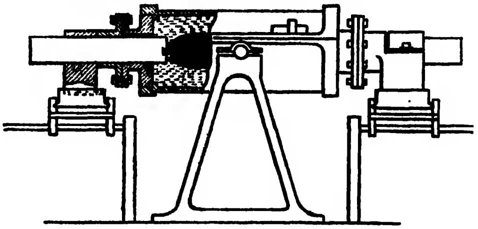

Fig. 8.—Horizontal furnace for fusion and removal of plastic mass for shaping after withdrawal of heating core (Bottomley and Paget's patent).

fused mass—in the form of a large tubular sausage—was found to retain its plasticity for a considerable time, due, as we now know, to the heat insulating effects of the unfused sand which adheres to the fusion. In consequence of this, the fusion could be drawn into tubes or blown out into moulds (see Exhibit 3, Fig. 1) or pressed or rolled (see Exhibit 2, Fig. 1) *without reheating.*

In the Thermal Syndicate's patents the working conditions are stated in terms of the current requirements for a specified size of heating core. Later researches by other workers have shown that the change from crystalline quartz to amorphous silica begins at 1470° C—that melting begins about 1,650°, and that the pasty condition is reached at between 1,750° and 1,800° C.

The material produced by drawing, blowing or pressing a sausage of fused silica sand differs from the products of Elihu Thomson and Hutton, in that the spherical bubbles of the former processes are drawn or spread out into threads or laminations, so that the material has a grain. This results in a characteristic change of appearance, as will be seen from the samples. The high lustre on the inside of blown fusions (see Exhibit 2, Fig. 2) has a practical use in the case of electric and gas-lighting bowls —it has also been used for mosaic work. (Exhibit 3, Fig. 2). The first important exhibition of vitreous silica ware or "Vitreosil" was made by the Thermal Syndicate at the Brussels Exhibition of 1910. These were, I believe, the only exhibits (except those of platinum shown by Johnson and Matthey) which survived the disastrous fire which destroyed the British Section. (Exhibit 4, Fig. 2). It was a good advertisement for the properties of fused silica, but (and I should like to emphasise this point) it was *not* the Thermal Syndicate who *lit* the fire!

One of the effects of this Exhibition was to stimulate certain German workers to imitate the processes described in the Thermal Syndicate's patents.

In particular Dr. Volker, between 1907 and 1910 developed a process in which the interior gaseous pressure for blowing the fusion into the mould was produced, not by introducing gas through a nozzle, but by dropping a slice of potato or other moisture-containing substance inside the fusion after withdrawing the heating rod and before closing it by mechanical pressure.

The fusion was thus blown up by internal steam pressure.

In Germany and in England this process was held to be an infringement of the Thermal Syndicate's patents and was discontinued.

In 1917 the Thermal Syndicate and the Silica Syndicate became associated and the transparent silica works of the latter were transferred to the Thermal Syndicate's works at Wallsend-on-Tyne.

We will now consider very briefly the various physical properties of our material and see how these have been utilised in practice.

The first outstanding property of fused silica—whether transparent or opaque—is its low co-efficient of expansion. (Fig. 9).

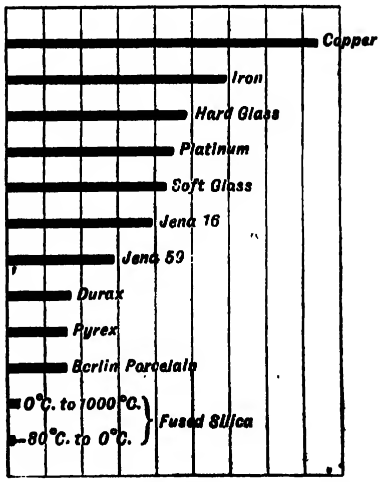

Fig. 9.—Chart comparing various co-efficients of expansion, drawn to proportional scale.

Fused silica is in a class by itself—its expansion being less than ⅛ of that of the best glass of the Pyrex type, and less than 1/20th of that of the high expansion glasses.

Dr. H. D. H. Drane, the Research Chemical Engineer of the Thermal Syndicate, has devised an effective experiment to demonstrate the relative expansion of fused silica—ordinary laboratory glass and metallic aluminium. A tube of fused silica is surrounded by a coil of resistance wire, which can be electrically heated. Inside the tubular furnace thus formed are suspended a rod of fused silica, a rod of glass and a rod of aluminium, which at room temperature are of such a length as just to project beyond the mouth of the silica tube. The shadows of the rods are seen, inverted, on the screen. (Fig. 10).

The practical effect of the low co-efficient of expansion is that one part of a mass of fused silica may be chilled and the other heated without straining the material sufficiently to crack it.

Here, for example, are similar pieces of fused silica, Jena glass and Pyrex glass, which we will heat in a bunsen flame and dip into cold water.

In each case the material cracks—except the silica—which is not surprising, seeing that the Pyrex and Jena glasses expand from six to nine times more than the silica.

We will now return to the heated tube and rods. The glass and aluminium rods have grown appreciably in comparison with the silica. (Fig. 10). Eventually the glass will soften and draw out (at c. 620° C.) and the aluminium will melt (at 657° C.), while the silica rod still shows no appreciable lengthening.* An interesting application of this property of low expansion with increase

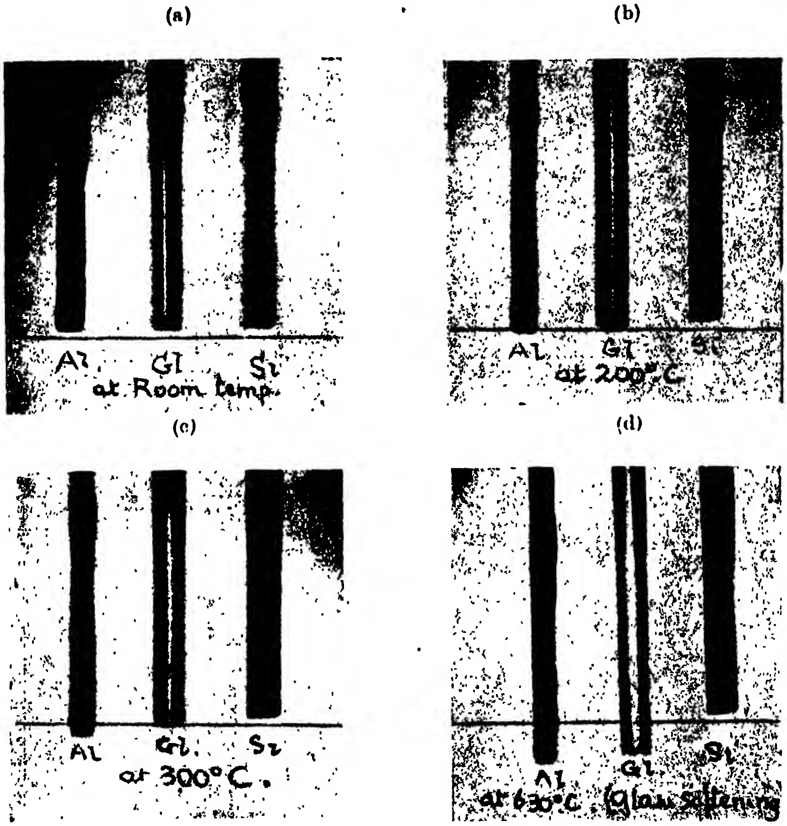

FIG. 10.

The current has now been turned on so as to heat up the silica tube and its contents. As the two rods are suspended from the top of the tube they will expand downwards and their inverted shadows will be seen to grow upwards.

As it will take some minutes for the tube to heat up, and as a watched pot never boils, we will get on with the lecture and return to our experiment in a few minutes.

* NOTE.—In the actual experiment the glass rod accidentally touched and became stuck to the silica rod! The illustrations, Fig. 10, are taken from a repetition of the experiment.

of temperature is in the use of fused silica rods as standards of length—for example, as in the standard metre of the N.P.L.

We may next take the *relating high softening point*, which is shown on the screen. (Fig. 11). This characteristic may

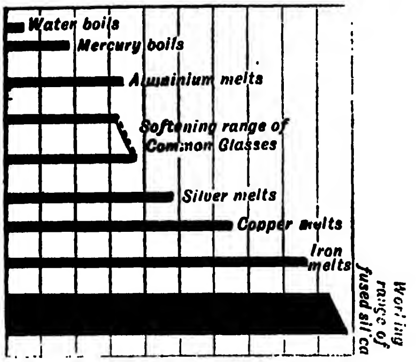

FIG. 11.—Chart comparing various fixed temperatures indicating high softening point of fused silica.

be demonstrated by heating three rods of silica, Jena glass, and Pyrex glass, each clamped horizontally at one end by three bunsen flames. The glass rods soon soften and bend, while the silica rod remains rigid.

Practical uses of these properties appear in such apparatus as muffles, retorts, pyrometer tubes and roasting trays, besides combustion tubes for high temperature determination. (Exhibits 4, 5, Fig. 1.)

The next characteristic is an *undesirable* one—that of devitrification on prolonged heating. This is accompanied by a reduction in volume of 3 to 5%, and the vitreous mass changes to a biscuit-like substance with a greatly reduced mechanical strength, consisting of crystals of silica in the form of crystobalite or tridymite—according to the temperature, time and other conditions of heating.

Fortunately, the action only begins at relatively high temperatures. N.P.L. tests show that loss of strength, through devitrification hardly commences at 1,120° C., but is appreciable after four hours' continuous heating at 1,140° C. Above this temperature continuous heating gradually converts vitreous silica into crystobalite. Heated continuously for *eight days* at 800° C. in the presence of a suitable catalyst, such as KCl. and LiCl, vitreous silica is converted into tridymite.

For some of the above and for certain other data in this lecture, I am indebted to the paper of Professor Georges Flusin, of Grenoble, in Chimie et Industrie, of June, 1920, which gives a valuable summary of the crystallography and other physical and chemical characteristics of fused silica.

Pure fused silica devitrifies less than silica mixed with any known substances.

As to *mechanical properties*, the density of transparent fused silica is 2.21—that of the opaque variety being 2.07. Its hardness is of the same order as that of hard glass.

On Mohs' Scale—

Glass	=4.2 to 6.2
Fused silica	=4.9
Quartz	=7.0 & 5.0 parallel to and perpendicular to the axis respectively.

In Kg. per mm^2 and for a sphere of 1 mm—

Fused silica	=223.
French glass	=130 to 265

Its modulus of elasticity measured in kg. per mm^2 is rather higher than Jena glass—6.6 as against 6.0. The crushing strength of fused silica is between that of granite and blue brick. Its tensile strength—when in the form of quartz fibres—is equal to that of high carbon spring steel. Its shear rigidity modulus, *i.e.*, the twisting force which, when applied to a cylindrical rod of unit length and diameter, twists the rod through unit angle—is slightly higher than that of crown glass.

Crushing Strength.	tons per sq. inch.
Granite	10.5
Fused silica	7.0
Blue brick	3.0
Common brick	1 to 2
Silica brick	.75 to 5.0

The mechanical properties are summarised in the following table :—

Tensile strength (breaking).	tons per sq. inch.
High carbon spring steel ..	70
Quartz fibre	70
Glass (bulk)	0.2 to 0.6
Opaque fused silica (from bending tests)	2.2

Shear Rigidity Modulus.	dynes per Cm^2	tons per sq. inch.
Copper ..	4×10^{11}	2.6×10^3
Quartz fibre ..	3×10^{11}	$2 \cdot \times 10^3$
Crown glass ..	2.9×10^{11}	1.9×10^3
Flint glass ..	2.3×10^{11}	1.6×10^3

On heating, fused silica becomes *more* resistant to shear up to about 1,000° C., being 7% higher at 850° than at normal room temperature. N.P.L. tests further

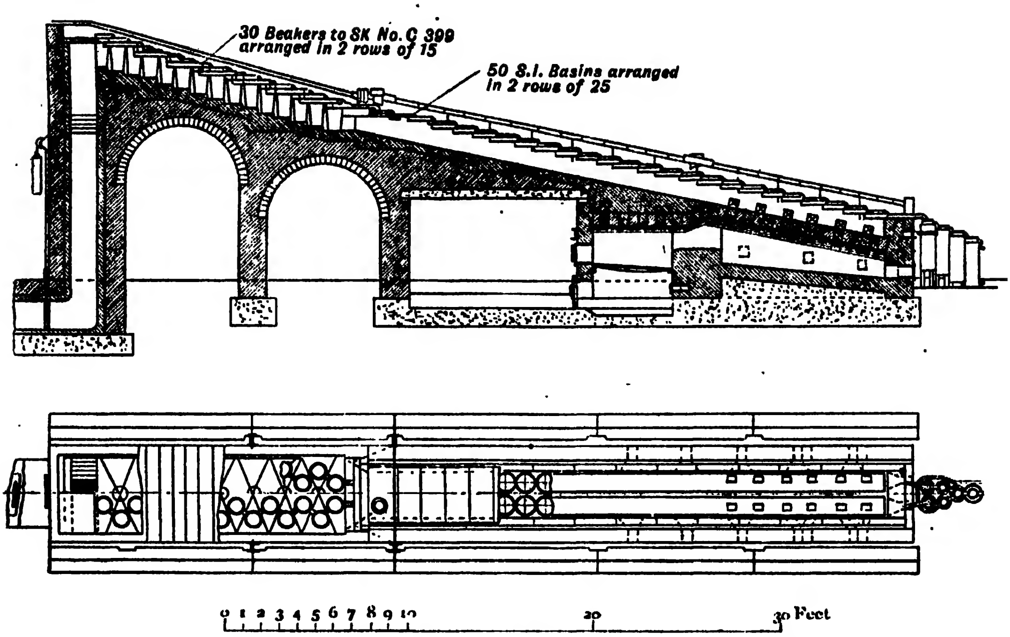

FIG. 12. Plant used for concentration of sulphuric acid, showing pre-heating vessels, concentration basins, and coolers.

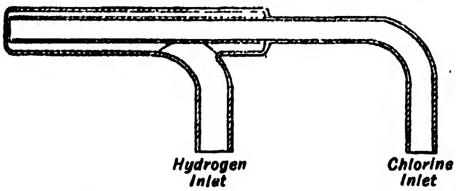

FIG. 13.—Silica burner used in the production of synthetic hydrochloric acid.

showed a permanent increase of strength after heating to 1,188° for four hours and allowing the material to cool due to the release of internal strain produced by the rapid cooling of the material after shaping in the plastic state.

The heat conductivity of opaque fused silica is practically the same as that of glass · 0.002 c.g.s. units. Its specific heat is 0.202

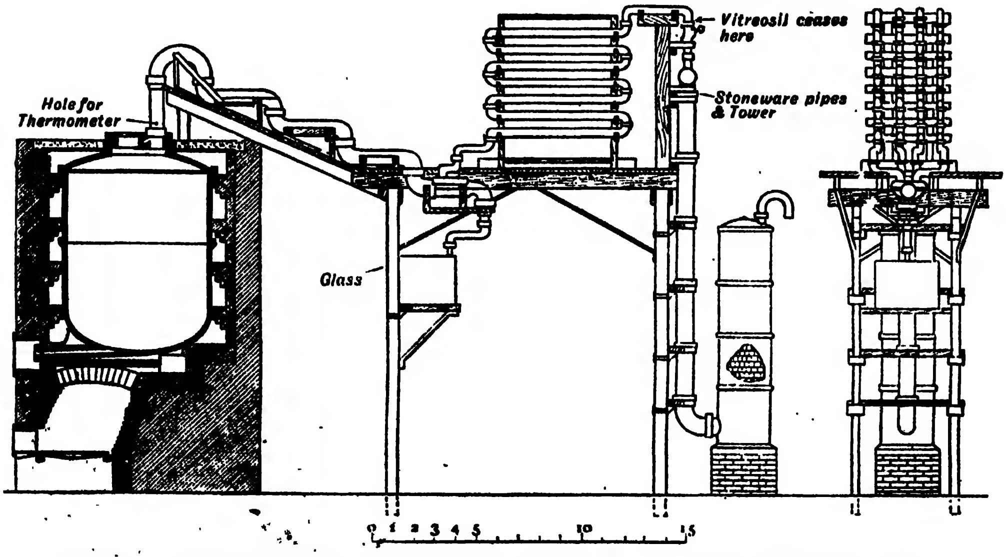

FIG. 14.—Nitric acid plant showing the use of fused silica for condensation unit.

at 100° C. and 0.290 at 1,000° C. In chemical properties the chief virtue of fused silica is its resistance to acids; its besetting sin is surrender to the alkalis and metallic oxides, with which it combines to form glasses.

As to acids, the material is entirely unaffected by any acids or mixtures of acids, except hydrofluoric (in which its solubility is 1/10 of that of glass) and concentrated phosphoric acid, in which it begins to dissolve appreciably at about 300° C.

Corrosion by H.F...	
Glass	1,000
Fused silica	100
Quartz (parallel and perpendicular)	11 & 1

Here are two similar pieces of glass and fused silica, which we will dip into strong hydrofluoric acid for a few minutes. The result is that the glass rod becomes whitened by the formation of gelatinous silica, while the silica rod is quite unaffected.

Acid resistance makes fused silica the ideal material for the production of concentrated acids; indeed, at the beginning of the war there was, I believe, no other material immediately available in this country. All the rest came from Germany.

Figures 12, 13 and 14 show one or two typical plants utilising vitreosil for:-

H_2SO_4—Concentration,

H-Cl—Burner for synthetic production of Hydrochloric Acid,

HNO_3—Distillation, respectively.

In Fig. 1, exhibit 6 shows a tray for acid concentration, 7 a flue pipe, 7a a 9 foot socketed pipe, 8 an S type acid condenser, 9 an 18″ diameter bend, 10 and 11 distilling vessels, 12 is a pyrometer tube. In Fig. 2, 4a is a cooler for acid concentration, 4b is the centre pipe for 4a, through which hot acid enters, 5 is a 60 foot coil for acid condensation.

Fused silica is also *quite* insoluble in water at boiling point (which is not the case with glass), and in consequence the International Atomic Weight Commission recommended the use of silica vessels for analytical operations of high precision—except, of course, for the heating of alkaline and basic compounds. In this connection it must also be remembered that fused silica begins to volatilise below its softening point and that at temperatures above 1,350° C small losses by evaporation begin to appear.

Owing to its resistance to steam and to temperature changes, transparent fused silica tubes are used as gauge glasses for steam boilers. (Exhibit 13, Fig. 1).

There is increasing recognition of the importance, in refined chemical work of avoiding contamination by the traces of alkali, which even chemically resistant glass ware will part with to certain reagents and solutions. Many instances of changes in sensitive solutions kept in glass vessels have been traced to the alkali of the glass. The use of bottles, flasks, beakers, etc., of fused silica obviates the risk of such contamination and chemical change.

Another and, so far, a purely disadvantageous property of fused silica is its permeability to gases at high temperatures.

Helium begins to diffuse appreciably at 180° C., hydrogen at 300° C., nitrogen at 600° C. This action increases with rising temperature. The diffusion rates at 500° C. are in the ratio He : H_2=22 : 1 ; at 600° C. H : N = 100 : 1. According to Johnson and Burt, a well evacuated bulb one litre capacity and of wall-thickness 1.5 mm. may be kept in air at 400° C. for 100 hours before the internal pressure reaches 10^{-4} mm.—the gas which enters the bulb being mainly nitrogen.

Turning now to the electrical properties, the most interesting is the low conductivity of fused silica at high temperatures.

	At 15° C.	At 150° C.
Fused silica	$> 2\times10^8$	$> 2\times10^8$†
Jena glass..	2×10^8	2×10^7†
Ordinary glass	5×10^5	1×10^5†
Porcelain	22×10^8	4×10^5

Though at ordinary atmospheric temperatures porcelain is considerably the better insulator, at 150° C. fused silica has 500 *times* the resistivity of porcelain.

The resistivity falls at higher temperatures thus:—

Temperature	230°C.	250	700	800
Resistivity in Megohms per c.m.³	2×10^7	2.5×10^2	3×10^1	2×10^1

Fig. 15 shows the temperatures at which the resistances of various insulators become equal to 1 megohm per cm.³*

Fused silica has the further advantage over porcelain and glass as an insulator of

† See Campbell. Proc.Phys.Soc. 1913. 25. 336-7.

* Note.—These data as to conductivity are from tests of the U.S.A. Bureau of Standards taken during the war.

being *less hygroscopic*, so that surface leakage is reduced.

The *specific inductive capacity* is relatively

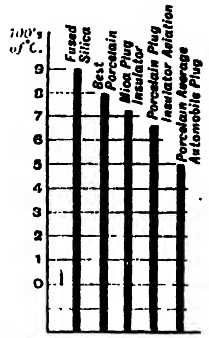

FIG. 15.—Chart showing temperature at which resistances of various insulators equal 1 megohm per cm. cube.

low—being 3.5 to 3.6 as compared with 5.6 for mica and porcelain.

Vaseline	2.2
Fused silica	3.5 to 3.6
Sulphur..	4.0
Mica	ca5.6
Porcelain	ca5.6
Glass crown to flint	5.0 to 10

The *dielectric strength* of fused silica is equal to that of the best glass :—

	K.V. per c.m.
Commercial insulating oil ..	50—100
Glass	75—200
Fused silica	100—200

Fused silica has been successfully used as a high tension insulator for direct current in Cotrell precipitation plants for the treatment of flue gases, under conditions of heavy arcing which caused all other insulators to break down.

As to *optical* properties, fused silica is, when free from bubbles, very transparent to ultra violet radiations, visible light, and heat.

We have here a solid rod of fused silica 120 c.m. long, of which one end can be heated to whiteness in the O-H blowpipe. (See Fig. 16). The other end is thickened so as to form a rough lens. The light passes—apparently undiminished in intensity and unaltered in colour—through a thickness of 120 c.m., *i.e.*, nearly 4 feet of fused silica; it will be seen that though the rod is bent through three right angles the light is internally reflected and keeps within the rod. Even an appreciable amount of *heat* passes through a great thickness of fused silica as is shown by the movement of the light spot on the galvanometer scale, when

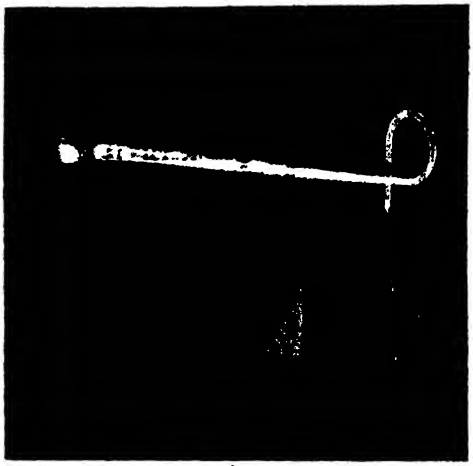

FIG. 16.—Transmission of light through silica rod.

a thermocouple is placed in the path of the emergent radiation at the cold end of a silica rod (but without a thickened end), and the other end of the rod is heated. In working short lengths of rod in the blowpipe the operator must take care not to burn his fingers in the radiant heat which emerges at the *cold* end of the rod!

The comparative transparency of fused silica to long wave-length radiation is shown in the following tables, which are due to Coblentz and Weniger in America.

	Thickness mm.	Source. Incandest. mantle 107 μ.	Hg.Arc. filtered through blackcard 310 μ.
Quartz ⊥ to axis	41.7	12.1%	58.9%
Fused quartz ..	2.0	12.5%	60.0%
Fluorite ..	.59	5.3%	42.2%
Glass ..	.18	2.1%	25.9%

Fig. 17 shows the relative transparencies of various substances to ultra violet radiation.

Fused silica is quite transparent to ultra-violet rays down to $\lambda = .226\ \mu$ to $.220\ \mu$, and to some extent down to 0.189 μ, whereas the most transparent glasses are transparent only down to $\lambda = .298\ \mu$.

Here is a quartz mercury-vapour lamp giving visible and ultra-violet light.

The visible and invisible light pass through a screen, either of *glass* or of fused silica and any radiations which pass through fall on a zinc plate connected to a charged electroscope.

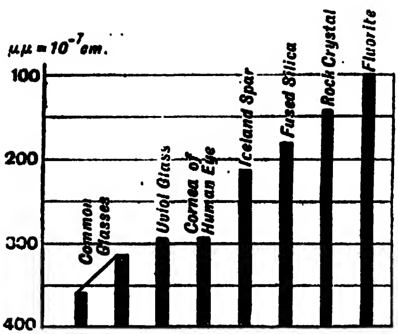

FIG. 17.—Chart showing relative transparencies of various substances to ultra-violet radiation.

The effect of ultra-violet light is, as is well known, to cause the charge to leak away by the discharge of electrons from the surface of a zinc plate, when negatively charged, so that the leaves of the electroscope fall together.

When the glass screen is interposed no leakage occurs. When the silica screen is substituted the leaves collapse rapidly, showing the great transparency of silica to the short wave radiations which discharge the electroscope.

The effect may be illustrated in another way, namely, by means of the chemical action of ultra-violet light on a solution of KI and starch, which is darkened by the chemical liberation of iodine in the solution.

Similar solutions in two vessels one of glass, the other of fused silica, are placed side by side in the beam of visible and ultra-violet light.

It will be seen that in a few minutes the solution in the silica vessel is appreciably darker than that in the glass—showing that the silica has allowed more of the chemically active rays to pass through into the solution.

For this reason fused silica mercury vapour lamps have been successfully used, especially in America, for the sterilisation of water and other liquids by the action of ultra-violet light.

The refractive index of fused silica for the D line is 1.4585.

So much for the optical properties of our material.

Besides the Thermal Syndicate and Silica Syndicate, there have been other workers in the field. The work of Dr. Volker, though put to an end in Germany, has reappeared in France and the U.S.A., but on a relatively small scale and so far, has not produced any distinctive products.

In U.S.A. the G.E.C. have in recent years carried on silica fusion at Lynn under Dr. Elihu Thomson, whose early work in 1902 has already been referred to.

A description of the products of these works is given in the *General Electric Review* for February of last year.

The most interesting technical advance by the G.E.C. is in the production of transparent rods and tubes by fusing rock crystal in vacuo in a tubular furnace and drawing the fused mass between water-cooled dies. Besides transparent ware, the G.E.C. have produced 6in. to 10in. molded insulators for H.T. work. It is curious that the writer of the G.E.C. article—which gives an historic résumé—is apparently ignorant of all the work which has been done in Europe since 1902. The G.E.C. is not usually 20 years behind the times!

Returning now to Thermal Syndicate products, the most important developments since the war have been in the manufacture of translucent globes for incandescent gas burners. These, though necessarily much more costly than glass, have proved so reliable that they are now very widely used. (See Exhibit 6, Fig. 2).

In these cases, as also in that of laboratory ware, the material is glazed on both sides by subsequent treatment, as distinct from the heavy chemical ware which is simply blown into a mold and has an external coating of unfused sand.

Another interesting development is the manufacture of large thermionic valves for W.T. work.

By the courtesy of the Admiralty and the Signal School, I am able to exhibit two valves of Signal School design, manufactured by the Mullard Radio Valve Co., of Balham, the fused silica parts being supplied by the Thermal Syndicate. (Exhibits 14 and 15, Fig. 1). The smaller valve is of 2.5 k.w., the larger of 10 k.w. output.

The T.22 type (10 k.w.) is that described by H. Morris-Airey, C.B.E., before the Inst.E.E. on March 7th, 1923. This valve has had considerable use. Exhibit 16 shows a still larger valve envelope 33″ by 8″ diameter.

The use of fused silica for laboratory ware is too well known to need further explanation.

By the courtesy of Messrs. Kelvin, Bottomley & Baird, I am able to show specimens of optical fused quartz made by the Thermal Syndicate and worked by them,

also a series of silica-enveloped mercury vapour lamps and a very interesting silica enveloped gas-filled lamp.

Here we have a collection of typical pieces of heavy chemical ware. At the beginning of this lecture I showed one of the first blown-out fusions produced at Wallsend in January, 1904. We have here a comparable fusion blown for the occasion of this lecture—20 years later. (See Exhibit 7, Fig. 2). This "flask" weighs 130 lbs. and has a capacity of 770 litres or 170 gallons.

Unlike the patience of this audience, the technical uses of fused silica are far from being exhausted. There are surely many new and useful applications lying in wait for those who have the wit to realise them.

I venture the hope that in another 20 years' time we may all be here to meet again and see the results of fresh technical advances as great in comparison as those which I have had the honour of demonstrating this evening.

APPENDIX.

LIST OF EXHIBITS.

	Fig.	Ref. No.
Specimens of Rock Crystal, "geyserite" sand, pure quartz sand	—	—
Fulgurites from Maldonado, and from Griqualand, South Africa	—	—
Tube of fused rock crystal made by Shenstone's method	—	—
Collection of transparent laboratory ware	1	1
Tube made by Hutton (resistance heated rod)	—	—
"Ostrich egg" fusion made January, 1904	2	1
First fusion blown by air pressure, 1904	—	—
First fusion blown into a mold, June, 1904—basin of 4 litres capacity	—	—
Early dome-shaped muffle, 12" x 6"	—	—
Sausage-shaped fusion, before manipulation	—	—
Section of sausage-shaped fusion	—	—
Trough 4' 6" long x 4" x 4", produced by rolling plastic fusion	1	2
Cluster of 170 small crucibles blown into mold	1	3
18" basin showing lustrous inner surface	2	2
Specimen of mosaic	2	3
Crucible 8" x 5¾" from the Brussels Exhibition fire	2	4
Large threaded tube for electric muffle 6' x 8" diam.	1	4
Small threaded tube for electric muffle 8" x 1" diam.	1	4
Type of small ignition dish in commercial use, 1907 2" diam.	—	—
Collection of opaque Vitreosil laboratory ware—crucibles, beakers, ignition trays, etc.	1	5
Specimens of devitrified silica	—	—
Large tray for acid concentration, 3' 4" x 1' 5" x 6½"	1	6
Flue pipe or drain for corrosive fluids	1	7
9' Socketed close-ended pipe	1	7a
S type bend acid condenser, 6' 6" centres	1	8
Socketed right-angled bend tube, 18" diam.		1
Distilling vessel closed top. 2' 5" x 1' 7" dia.	1	10
Luted top distilling vessel, 2' 3" x 1' 8" dia.	1	11
Cooler pot for concentrated acids	2	4a
Centre pipe for sulphuric acid cooler pot	2	4b
Tube used for pyrometer observation in Kilns, etc., 4½" diam. x 3'	1	12
Boiler gauge glasses of transparent silica, 1' 6" x ⅞" ext.	1	13
Collection of Vitreosil gloves for incandescent gas burners	2	6
First inner and outer glazed tubing produced, about 1" x 6"	—	—
W.T. Valves 2.5 K.W.	1	14
10 K.W.	1	15
32" x 8" envelope	1	16
Optical fused quartz, worked by Messrs. Kelvin Bottomley & Baird	—	—
Silica enveloped mercury vapour lamps (Thermal Syndicate, Ltd., and Kelvin Bottomley & Baird)	—	—
Silica enveloped gas-filled lamp (Thermal Syndicate, Ltd., and Kelvin Bottomley and Baird)	—	—
Flask-shaped vessel, 170 gallons capacity	1	7

DISCUSSION.

THE HON. SIR CHARLES A. PARSONS, K.C.B., F.R.S., said that in 1887 he carried out some experiments in which silica sand was fused by means of an electrically-heated carbon rod. It was quite unintentionally on his part, while he was investigating some other problem, that he came upon the possibility of fusing silica in this way. His object was to make hard carbon rods which, by this treatment, were increased in density from 1.6 S.G. to 2.4, and it was hoped would last longer in arc lamps of his firm, and not to make fused silica. But having succeeded in fusing silica he communicated the results to the Royal Society. He must say that he shared the author's astonishment at the statement of the early work on this subject which appeared in the *General Electric Review*, and he would like to suggest that when the author's paper was published in the Journal, 100 copies should be sent to Dr. Elihu Thomson for his enlightenment. He thought that the Society should be very much indebted to the author that evening for giving the first full and unreserved explanation of the manufacture and use of fused silica.

SIR ROBERT HADFIELD, Bt., D.Sc., F.R.S., said that the chief thing he had to mention about the paper was that they were all greatly indebted to the valuable work done by the Thermal Syndicate Company at Wallsend. Fused silica had proved

to be a very valuable property in the laboratories of which his own firm had control. They had avoided breakages and other disagreeable results by using this product. A gentleman in the audience whom he was glad to see was Mr. Darling, who, he thought, was one of the first to call attention to this very valuable product. He was very glad to hear Sir Charles Parsons's remarks that evening, and his reference to America was, he thought, quite in order. It was not uncommon for people to imagine that no work had been done on a particular subject outside their own country. The Germans were rather fond of taking certain things and claiming them to be entirely their own. In one of the leading technical journals issued that week he noticed a reference to a book published in Germany, in which the author suggested that Germany had introduced all the improvements in iron and steel! They might take that for what it was worth. He himself came from Sheffield, where they were very much indebted to silica. Had it not been for the presence of a certain siliceous compound in the neighbourhood of that city, it was very probable that Sir Henry Bessemer would never have carried his wonderful process to the success that he did. Bessemer was hindered in his early work by the fact that the linings of his converters, being made of destructible material, melted away, but he came down to Sheffield where they had this valuable deposit of ganister, which was a very pure form of silica, and with this as the material for his lining he achieved great success. In Sheffield, therefore, they had good reason to be indebted to the valuable material called silica. He remembered speaking to Sir Henry Bessemer, who told him how much be was indebted to the Sheffield deposits. The speaker was sure that there were many experts present who knew far more about the matter than he did himself, and he would only thank the author warmly for a valuable paper.

PROFESSOR C. V. BOYS, F.R.S., wished to join in expressing his very great pleasure at the paper. As the author had explained to them, it was not the first time that he (the speaker) had seen fused silica, but it was the first time that he had realised how many wonderful things, such as were exhibited that evening as if they were quite common stuff, were made. He would not put before the Society any work of his own, except to say that it was 37 years ago that, in drawing his quartz fibres,[1] he worked with silica in the purest form he could obtain, rock crystal, and he recognised, even at that time, its wonderful properties.[2] Only by working with pure optical quartz out of contact with any other body could he get the clear transparent fused rods with which he made the quartz fibres. He might tell the author how he made a quartz tube which he showed at the meeting of the British Association in Leeds.[3] The author had described the placing of parallel rods around a core, but he (the speaker) made his tube by taking a rod and melting it and winding it around nothing at all. He kept on doing so until at last he got a tube. Having made that tube hot with the oxy-hydrogen blow-pipe, which alone he had to use, he drew it out into a finer tube, and from this made the clear transparent bulb which he showed at Leeds. He said at the time that that was the forerunner of greater things, and in that respect he thought he was a good prophet. He had been a little surprised at one remark which had fallen from the author, about porcelain being a better insulator than fused quartz. He would like to know whether the fused quartz to which the author had referred was a really pure quartz, or whether impurity of any sort had been allowed to come upon it. He had made experiments upon the conductivity or insulating properties of fused silica[4] as follows:—He took a rod made of pure lead glass, drawn out, and put it into an atmosphere kept dry by sulphuric acid. From it a pair of gold leaves of an electroscope were suspended, charged, and the rate at which they fell together denoted the rate at which the electricity escaped. He noted the result when a rod of the purest lead glass was used in air chemically dried by sulphuric acid. Then he took a corresponding rod of fused quartz. This he dipped into water and put it into a box in which water was liberally sprinkled so that the air was saturated, and he found that the rate at which the gold leaves came together, and at which the electricity escaped, was the same under these conditions as before. In other words, the experiment showed the conductivity of the air, the rods by comparison being perfect insulators. As this was the case, he could not understand how anything could be found to be a better insulator than really pure fused quartz. In conclusion, he could never have imagined, working on the small scale of 37 years ago, that he would live to see such things as he saw there that evening, and it was a great pleasure to him to see them.

DR. R. S. HUTTON desired to point out that the paper did not quite do justice to the work which the author himself had done. Sir Richard Paget was one of the few to realise the possible industrial developments and applications of this material. Quite in the early days—as far back as 1902—the author had been interested in the work of other people on this subject, and wrote him to the effect that he wanted to look round and discover what were the possibilities of the industrial manufacture. The speaker felt perfectly convinced, knowing as he did, something of the early history of the subject, that had it not been for Sir Richard Paget's foresight at that time, they might be now in the same position as the General Electric Company apparently imagined the English work to be. He would like to say also that with regard to Professor Elihu Thomson's article, to which he had had his attention drawn some few months ago, he was astounded to find how Professor Thomson had stated the course of events. He happened to have a very good opportunity of understanding Pro-

1.—*Phil. Mag.* June, 1887.
2.—*Proc. R. Inst.* June, 1889. *Phil. Mag.* July, 1890.
3.—*Nature*, vol. xlii. 1890.
4.—*Phil. Mag.* July, 1889.

fessor Thomson's position with regard to fused quartz in the year 1902. In that year the speaker read his first note on the electric fusion of quartz before the Manchester Philosophical Society, and later in that year he went over to the United States and read another paper on the subject before the American Electro-Chemical Society. At that meeting, Dr. W. R. Whitney, who was now head of the General Electrical Research Department, came to him and mentioned that Professor Elihu Thomson had been working on quartz, and had suggested that he should visit him. The speaker had the habit in those days of keeping a diary, and, recently, after his attention had been drawn to the article in the G.E.C. Review, he looked up two passages written in his diary during his American visit, according to which he had not been at all impressed by the work which was done at that time in America. All that the speaker would claim was that Professor Thomson's work and ideas had not in any way contributed to his own results, nor to the subsequent English developments based thereon.

The investigations of Professor Thomson and himself were quite independent of one another, but so far as the resistance method of heating was concerned, both had apparently been forestalled by the earlier work of Sir Charles Parsons.

There was one other point to be mentioned. The author in his paper gave a picture of one of the first experiments, and showed the MSS. giving an account of the subject in the writing of the late Dr. Bottomley. If the experiment referred to was the one which he himself remembered very well, it was carried out on a certain Saturday morning when they were all working very much against time. They had taken off their coats and were shovelling something like a ton of sand, or, at least, many hundredweights, in order to build a rough furnace to a height of probably 4 ft. or 4 ft. 6 ins. from the floor. After they had completed their work and turned on the current, they were appalled to see the whole mass of this material rise up before them. They sat down and almost wept with disappointment, but before they had gome very far in their despair, they realised that, through an accident, they had found the secret of working the quartz. Up to that time they had gradually succeeded in softening and melting it, but the circumstance just described gave them the real clue to the mass working of the material. This probably was the actual experiment to which the author had referred. At any rate it was very vivid in his recollection. It was one of those experimental disappointments which, as so often happened, pointed the way to a greater success, and the success in this case had been wonderfully exploited by the Thermal Syndicate.

Mr. Charles R. Darling added his thanks to those of previous speakers for the splendid description of the making of vitrified silica which appeared in the paper. Formerly there was a certain amount of mystery about the process, and he was glad that the lecturer had "taken the lid off" completely. The secret things, as Sir Robert Hadfield once said were never any advantage. It was always better to let people know the secrets of a process, unless, of course, to do so was attended by the liability to some financial loss. After the paper of that evening they would be able to see clearly exactly how this material was made. He could not claim to have had anything to do with the early making of silica, but he could claim to have been a pioneer with regard to the use of it. He was one of the first to use silica tubes for simple electrical resistance furnaces. He was at that time working with pyrometers and using resistance furnaces with porcelain tubes. If one switched on a strong current suddenly the tubes always cracked, and one was always having to renew the tubes. The moment silica tubes were made he procured them, and he found them stand up to the conditions almost indefinitely. He told others of his experience and published it in various quarters, and now silica was the material used all over the world in very large quantities in the electric tube furnace and muffle furnace. This was one little industry which had grown out of the production of vitrified silica. The author had stated that if the vitrified silica were heated continuously for eight days at 800° C., the whole of the vitreous silica was converted into tridymite. The speaker's own experience was that one could use it not for eight days, but for eight months, provided that one did not get metallic oxide impurities. He thought that the statement in the paper, if left unqualified, would lead to misunderstanding. The fact was that vitrified silica might be used under these conditions almost indefinitely, but if the metallic oxide were incorporated it caused fluxing, and that was the weak point in the use of silica. He asked whether anything had been done with zirconia, whether there was any prospect of making zirconia tubes on these lines, because zirconia was not attacked by most of these metallic oxides. The whole subject reminded one that it was not always the chemical composition which mattered, but the physical condition was often of much greater importance. The fusing of silica—bringing it into a condition in which it was rarely found in nature, and then only accidentally—made all the difference in its properties; the heat treatment of this material brought about profound changes, and, no doubt, research with other minerals would show similar changes.

The Chairman (Sir Herbert Jackson) said that the Society was to be congratulated on having had this exceptional paper. The author had given them a very clear picture of the whole subject. He confessed that he was amazed as he looked round the room and saw the various articles exhibited, especially the "flask," which the author had exhibited at the end of his paper. It was only lately that the usefulness of fused silica had been really recognised. He himself spoke with the utmost gratitude for the work of the pioneers, for to-day there were many laboratory and industrial processes which it would be almost impossible to carry out without silica apparatus. Not only

was silica of use in many respects, but it also added, as they would appreciate from the exhibits, a touch of beauty in many directions. He felt confident that there was a great artistic future for this product. Taking up a number of small exhibits of bowls and the like, he asked the audience to notice how beautiful they were when worked in this translucent material. In glass dishes certain kinds of cooked food looked very ugly and unappetising, but when the dishes were made of translucent silica, there would be a beauty about the appearance which clear glass could not rival. He would not take up the time of the audience much further, because he knew that the members were eager to make a closer inspection of the articles which the author had brought to illustrate his paper, but he wished to express their indebtedness to Dr. Drane, the Research Chemist of the Thermal Syndicate, who had assisted Sir Richard Paget in his lecture. He knew that Dr. Drane was hard at work on some most interesting researches, and he was looking forward to another paper which would deal with the further developments now in a commencing stage. It had been a great pleasure to hear at first hand an account of this wonderful process, and he asked the audience to offer to Sir Richard Paget a very hearty vote of thanks for a remarkable and interesting lecture.

Sir Richard Paget, in reply, said that Sir Herbert Jackson had been altogether too appreciative; but that was just like him, and he supposed he could not help it.

With regard to the question asked by Professor Boys about the conductivity of silica, what he had said in his paper was not an observation of his own, but he had taken the results from a series got out by the U.S. Bureau of Standards in connection with their tests for various insulators. He was glad to hear from Professor Boys that the case for fused silica at ordinary temperature was so much better than he had been led to suppose.

Dr. Hutton's account of the original experiment was, of course, to be preferred to his own, because Dr. Hutton was present on that memorable occasion and the speaker was not. He had no doubt that the experiment was exactly as Dr. Hutton had described it, and very likely the type of furnace used for that experiment was not actually the one he had shown on the screen.

With regard to Mr. Darling's question as to the possibility of using zirconia, experiments had been made in fusing zirconia, but he was afraid that this line of research was fruitless, because zirconia had quite a high efficiency of expansion and tended to crack on cooling. It failed to arrive at the stage of plasticity like silica, though, of course, it might be used as an aggregated material.

The vote of thanks was then accorded unanimously.

LA VIE INDUSTRIELLE EN FRANCE.

Nouvelles Automobiles à Gazogène.

Des essais ont été faits dans divers pays, depuis assez longtemps déjà, pour actionner des automobiles au moyen de gazogènes, mais les applications industrielles de ce système ont été peu nombreuses jusqu'ici. Cependant, il y a deux ans, l'Automobile-Club de France a institué un concours de véhicules à gaz pauvre, qui a donné des résultats vraiment intéressants: six véhicules ont fonctionné normalement pendant un mois; celui qui fut classé premier était de construction anglaise, mais presque tous ont présenté les qualités nécessaires pour un fonctionnement industriel normal.

Depuis lors, l'intérêt très grand qu'il y a pour la France à réduire sa consommation d'essence, a conduit d'autres constructeurs à étudier la question. Ainsi, la Maison Berliet de Lyon, vient de construire deux véhicules: un camion et une voiture de tourisme, actionnés par un nouveau type de gazogène à charbon de bois. Ce gazogène, du système Imbert, est formé d'une simple caisse en tôle mince, sans revêtement réfractaire, dont la section verticale est trapézoïdale. A la base se trouvent deux tuyères se faisant face, par lesquelles l'air pénètre sous l'influence de l'aspiration du moteur. Entre ces deux tuyères, il se trouve une zone de combustion à très haute température, au centre de la masse de charbon de bois. Grâce à cette température très élevée, il ne se forme que de l'oxyde de carbone; la zone de combustion étant localisée au centre du gazogène, les parois ne sort pas très chaudes, et on a pu éviter l'emploi d'un revêtement réfractaire: aussi, le gazogène ne pèse pas plus qu'un réservoir d'essence. Les cendres sont fondues et tombent à la base de l'appareil. Dans la voiture de tourisme, le gazogène est placé à l'arrière, et l'aspect de la carosserie n'est guère différent d'une carosserie ordinaire.

Le gaz traverse le charbon, puis passe dans des chambres tubulaires en tôle disposées sur les côtés, où il se refroidit. Il traverse ensuite un cylindre dépoussiéreur, rempli de limaille imbibée d'huile. Avant son arrivée aux cylindres, il se mélange, enfin, au moyen d'un robinet, à la proportion d'air nécessaire.

La Distribution de Chaleur par Centrales thermiques dans les Groupes d'Immeubles, à Paris.

Depuis la guerre, la construction des maisons d'habitation dans les grandes villes, et principalement à Paris, est presque entièrement suspendue, à cause de l'augmentation du prix des matériaux et de la main d'oeuvre. Quelques vastes entreprises ont été, cependant, organisées depuis peu, mais elles ont adopté une formule nouvelle. Elles construisent de vastes groupes d'immeubles

divisés en nombreux appartements qui sont, non pas loués, mais vendus de 30,000 à 200,000 francs, aux personnes qui désirent les habiter. Celles-ci deviennent ainsi propriétaires de la partie de l'immeuble qu'elles habitent, et elles paient annuellement une somme représentant simplement l'entretien et les services communs, tels que le chauffage.

Cette combinaison a permis l'édification de groupes d'immeubles très importants, dans lesquels on a pu appliquer pour la première fois le système de distribution de chaleur à partir d'une station centrale. Ce système avait reçu jusqu'ici surtout des applications en Amérique, mais n'avait pas encore été employé en France.

Un groupe de 17 grands immeubles à 7 étages, actuellement en construction, à Paris, doit être chauffé par une centrale thermique unique. La puissance horaire de l'installation est de 1,485,000 calories (5,900,00 B.T.U. environ). Le chauffage est assuré par des radiateurs à eau chaude, au nombre de 1150 ; les plus éloignés de la chaufferie en sont à une distance de 350 mètres (382 yards). La circulation d'eau chaude est forcée au moyen d'une pompe centrifuge, actionné par une turbine à vapeur à basse pression. L'eau est chauffée dans 8 chaudières. On estime que ce système permet de réaliser une économie de plus de 25% par rapport à la dépense qu'aurait nécessité le chauffage indépendant de chaque maison.

Viaduc en Béton armé, a Arcs de 190 Mètres (625 feet) sur l'Elorn, a Plougastel, près de Brest.

On va bientôt construire un viaduc monumental en béton armé sur l'embouchure de l'Elorn, entre Brest et Plougastel - Daoulas. Cet estuaire présente une largeur de 700 mètres et le programme imposait de réserver une passe navigable de 70 mètres, avec une hauteur de 36 mètres dans la partie centrale. L'ouvrage doit supporter la chaussée d'une route et permettre, en outre, l'installation ultérieure d'un chemin de fer à voie normale.

Le projet adopté comporte trois grands arcs de 190 mètres (environ 625 feet) de portée chacun prenant appui sur deux piles en rivière, et surmontés d'un double tablier, le tablier supérieur portant la route et le tablier inférieur la voie ferrée. L'ouvrage est prolongé de chaque côté par deux viaducs d'accès, distincts pour le chemin de fer et pour la route ; sa longueur totale est supérieure à 800 mètres.

Le double tablier offre de grands avantages. Au point de vue de la circulation sur la route, ils sont évidents : la chaussée reste entièrement libre et tout risque d'accident est écarté. Au point de vue esthétique, le double tablier permet d'obtenir une puissante membrure horizontale supérieure, de dimensions en harmonie avec les proportions générales de l'ouvrage. Au point de vue construction, ce système fournit une poutre très rigide, capable de se porter sur de grandes longueurs, ce qui permet de réduire au minimum le nombre de supports verticaux.

La principale difficulté vient des circonstances locales qui interdisent, pour l'établissement du cintre, l'emploi de points d'appui intermédiaires entre les piles et culées. Cette difficulté sera résolue par l'emploi d'un cintre retroussé analogue à celui qui a été employé pour la construction des hangars à dirigeables d'Orly, près Paris, et qui franchira d'un seul jet l'espace libre entre les retombées des voûtes.

Les quantités de matériaux à mettre en oeuvre sont supérieures à 20.000 mètres cubes pour le béton et à 1.200 tonnes pour l'acier.

La Fabrication des Tuyaux en Ciment armé, par Centrifugation.

Les tuyaux en ciment, armé ou non, sont très employés, en raison de leur prix peu élevé et de leur forte résistance. Si certaines précautions sont prises, on peut aussi les rendre étanches ; cependant, par un simple pilonnage à la main, on obtient difficilement une étanchéité suffisante, et on ne peut guère descendre au-dessous de 30 centimètres de diamètre. Par centrifugation, au contraire, on peut obtenir une meilleure étanchéité et fabriquer en toutes dimensions. Cette fabrication s'est développée récemment en France, notamment au moyen du procédé Caron, exploité par la Société des Tuyaux et Agglomérés centrifugés, qui possède plusieurs usines en France.

Dans un moule cylindrique horizontal, on introduit une quantité déterminée de béton de ciment gâché assez clair ; on l'étale en remuant simplement le moule à la main ; puis on fait tourner pendant trois minutes ; on laisse prendre pendant 24 heures, à une température d'environ 20° ; on démoule : on laisse durcir pendant trois ou quatre jours à l'abri du soleil ; on laisse ensuite les tuyaux au parc pendant deux mois avant de les mettre en usage.

Les joints longitudinaux du moule pourraient laisser échapper, par leurs fentes, le mortier fin de ciment, ce qui créerait, tout le long du tuyau, deux zones de faible résistance. M. Caron vite ceci en enroulant à l'intérieur du moule une feuille de caoutchouc qui enveloppe le béton et empêche toute fuite du ciment.

La fabrication des tuyaux armés est tout aussi simple. On place l'armature dans le moule, avant d'y introduire le béton, et on opère ensuite comme pour le tuyau non armé.

CORRESPONDENCE.

NEW USES FOR RUBBER.

With reference to the above paper published in the *Journal* of March 14th, I consider that rubber blocks for road paving should be three times as long as ordinary wood blocks and have twice the width of the thickness, and also should have "ribbed" faces parallel to the sides of the pavement.

These blocks in my opinion, would not twist, and would prevent side-slipping.

It is evident that with the heavy motor traffic of to-day, rubber blocks do *not* eliminate noise.

D. R. BROADBENT,
A.M.I.E.E., A.M.I.M.E.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at 8 o'clock.

APRIL 9.—FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum." PROFESSOR C. VERNON BOYS, F.R.S., will preside.

APRIL 30.—BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "The London Dock District and its Roads."

MAY 5 (Monday).—T. THORNE BAKER, "Photography in Industry, Science and Medicine."

MAY 7.—J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation." ADMIRAL OF THE FLEET SIR HENRY JACKSON, G.C.B., K.C.V.O., F.R.S., will preside.

MAY 14.—

MAY 21.—(Trueman Wood Lecture.) SIR WILLIAM J. POPE, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, "The Outlook in Chemistry."

MAY 28.—MRS. ARTHUR MCGARTH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock:—

MAY 2.—JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced:—

BHUPENDRA NATH BASU, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

DOMINIONS AND COLONIES SECTION.

TUESDAY, MAY 27, at 4.30 o'clock.—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

WEDNESDAY, JUNE 4, at 4.30 o'clock.—THE RT. HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates."

MONDAY, JUNE 16, at 4.30 o'clock.—C. V. CORLESS, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada."

COBB LECTURES.

Monday evenings, at 8 o'clock:—

DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, "Certain Fundamental Problems in Photography." Three Lectures. March 24, 31; April 7.

LECTURE III: APRIL 7.—Photohalides and the visible image. Sensitising action of silver ions. Latent image. Duplication of light action by chemical agents. Silver halide grain as the unit. Sensitive centres on the grains. Nucleus exposure. Nature of the sensitive centres.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, APRIL 7 ... Geographical Society, 135, New Bond Street, W., 8.30 p.m. Captain P. K. Boulnois, "On the Western Frontier of the Sudan."

Surveyors' Institution, 12, Great George street, S.W., 8 p.m.

Transport, Institute of, at the Institution of Electrical Engineers, Victoria Embankment, W.C., 5.30 p.m. Mr. H. A. Watson, "Organisation of Traffic and Locomotive Departments in relation to Running."

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Prof. F. C. Roget, "The Influence of Calvin down the Centuries on the Religious and Political Development of the Protestant Nations."

Chemical Industry, Society of (London Section), at the Royal Institution, Albemarle Street, W., 8 p.m. Prof. Armstrong, "Sir James Dewar as an Experimental Inquirer."

Royal Institution, Albemarle Street, W., 5 p.m. General meeting.

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W. 5.30 p.m. Mr. A. C. Ionides, "Gas-Firing (Flame Control)."

TUESDAY, APRIL 8 ... Petroleum Technologists, Institution of, at the Royal Society of Arts, John Street, Adelphi, W.C. 5.30 p.m. Mr. W. J. Wilson, "The Crude Oil of Burma and Assam."

Royal Institution, Albemarle Street W., 5.15 p.m. Sir I. Gollancz, "Some other Aspects of 14th Century Poetry." (Lecture II.)

Metals, Institute of (Local Sections), Armstrong College, Newcastle-on-Tyne, 7.30 p.m. Annual general meeting. Chamber of Commerce, New Street, Birmingham. 7 p.m., annual general meeting.

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. P. J. Higgs, "Observation Notes on a 20,000 ton Ship with Oil Engines and Electric Propulsion."

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Dr. J. H. Hutton, "The Use of Stone in the Naga Hills."

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W., 5 p.m.

Photographic Society, 35, Russell Square, W.C., 7 p.m. Messrs. K. C. D. Hickman and D. A. Spencer, "The Washing of Photographic Products." (Parts III. and IV.)

Chadwick Public Lecture, at the Royal Society of Medicine, 1, Wimpole Street, W., 5.15 p.m. Dr. C. Porter, "American Public Health from an English Point of View."

WEDNESDAY, APRIL 9 ... Meteorological Society, 49, Cromwell Road, S.W., 5 p.m. 1. Mr. L. D. Margary, "Glaisher Stand *versus* Stevenson Screen. A comparison of 40 years' observations of maximum and minimum temperature as recorded in both screens at Camden Square, London." 2. Mr. R. Hill, "A lens for whole sky photographs." 3. Mr. F. J. W. Whipple, "The significance of regression equations in the analysis of upper air observations."

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5.15 p.m.

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W., 11 a.m. Annual meeting. 1.—Address by the President, the Duke of Northumberland. 2.—Admiral of the Fleet, Sir Doveton Sturdee, Strategical and Tactical Considerations governing Warship Design."

THURSDAY, APRIL 10 .. Pottery and Glass Trades Benevolent Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.45 p.m. Mr. P. W. V. Brooks, "Helpful Hints to Salefolk."

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Royal Institution, Albemarle Street, W., 5.15 p.m. Dr. E. J. Allen, "Scientific Research on Sea Fisheries." (Lecture II.)

Metals, Institute of, at the Institute of Marine Engineers, 85, The Minories, E., 8 p.m. Dr. G. H. Gulliver, "Failures in Metals and Alloys."

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Dr. T. P. Nunn, "The Philosophy of Gentile."

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W. Annual meeting continued. 11 a.m.:—1. Mr. A. Hurd, "The Future of Sea Transport." 2, Commander C. D. Burney, "Development of the Airship, with special reference to Transport." 3. Sir Alfred Read, "Sea-borne Coastal Trade." 3 p.m.:—1, M. P. Payne, "Results of some rolling experiments on Ship Models." 2, Professor K. Suyehiro, "The Drift of Ships caused by rolling among Waves." 8 p.m.:—1, Mr. R. W. Allen, "Application of Steam Turbines to Auxiliary Machinery." 2. Messrs. F. G. Martin and A. T. Wall, "High Elastic Limit Mild Steel and its General Applications."

Historical Society, 22, Russell Square, W.C., 5 p.m. Miss I. Wright, "The English Expedition against St. Domingo (1655) from Spanish Official Records."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Annual General Meeting.

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Mr. S. C. Bartholomew, "Power Circuit Interference with Telegraphs and Telephones."

Mechanical Engineers, Institution of, (South Wales Section), at the South Wales Institute of Engineers, Cardiff. Mr. J. P. Udal, "Payments by Results." (Graduates' Section, N.W. Branch). Engineers' Club, Albert Square, Manchester, 7.15 p.m. Mr. F. W. L. Heathcote, "Involute Gears."

FRIDAY, APRIL 11 London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Mr. J. Slater, "The Strand and the Adelphi."

Cyclists' Touring Club, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7.30 p.m. Annual General Meeting.

Naval Architects, Institution of, at the Royal United Service Institution, Whitehall, S.W. Annual meeting continued. 11 a.m.:—1, Eng.-Commander R. Beeman, "Further Experimental Work on Diesel Engines." 2. Mr. H. W. Nicholls, "Vibration of Ships." 3. Mr. G. Vedeler, "The Torsion of Ships." 3 p.m.:—1, Mr. J. L. Kent, "The Effect of Wind and Waves on the Propulsion of Ships." 2, Dr. T. E. Stanton and Miss D. Marshall, "The Effect of Length on the Skin Friction of Flat Surfaces." 3. Mr. A. Shigemitsu, "Skin Friction Resistance and the Law of Comparison." 4. Mr. J. Tutin, "The Analysis of Ship Resistance."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Dr. T. Moss, "The Relationship of Air-Consumption to Brake Horse-Power in Internal Combustion Engines; Road and Flight Tests."
(Midland Branch), Chamber of Commerce, New Street, Birmingham, 7.30 p.m. Mr. R. A. R. Cole, "The Manufacture of Chilled Iron Rolls."

Aeronautical Engineers, Institution of, at the Engineers' Club, Coventry Street, W., 6.30 p.m. Mr. S. M. Viale, "Radial Engines for Aircraft."

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Annual General Meeting.

Royal Institution, Albemarle Street, W., 9 p.m. Prof. J. Thorpe, "Colours, Stains and Dyes."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. J. H. Vickers, "The Photography of Wild Birds and Animals."

Metals, Institute of, The University, St. George's Square, Sheffield, 7.30 p.m. Annual General Meeting. Mrs. A. Vellan and Prof. Desch, "The Protection of Aluminium by Electro-Plating."

Physical Society, at the Imperial College of Science, South Kensington, S.W., 5 p.m.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W., 8 p.m.

Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.

Medical Officers of Health, Society of, 1, Upper Montague Street, W.C., 5 p.m. Dr. G. H. Miles, "Industrial Psychology and the Public Health."

SATURDAY, APRIL 12 .. Royal Institution, Albemarle Street, W., 3 p.m. Dr. C. Singer, "Leonardo da Vinci as a Man of Science."

Journal of the Royal Society of Arts.

No. 3,725. VOL. LXXII.

FRIDAY, APRIL 11, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

TRUEMAN WOOD LECTURE.

In consequence of illness, PROFESSOR C. VERNON BOYS, F.R.S., will be unable to deliver the Trueman Wood Lecture on "Calorimetry," which he had arranged to give on WEDNESDAY, MAY 21st. His place will be taken by SIR WILLIAM J. POPE, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, who has chosen as his subject, "The Outlook in Chemistry."

SEVENTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 2nd, 1924; LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Aisinman, Dr. Semion, Paris, France.
Crichton, Alexander, New Brunswick, Canada.
Fazul, Mehr Ali, L.C.E., A.M.I.E., Hyderabad, Deccan, India.
Fern, William G., London and South Africa.
Mepham, George S., St. Louis, Missouri, U.S.A.
Miolée, Willem Frederik, Bulawayo, South Africa.
Moll, Thomas, Bedford.
Parsons, Frederick, Massachusetts, U.S.A.
Robertson, James Alexander, O.B.E., J.P., Cleveleys, via Blackpool.
Rusk, Professor Rogers D., M.A., B.S., Napcrville, Illinois, U.S.A.

The following candidates were duly elected Fellows of the Society:—

Agnew, Andrew, C.B.E., London.
Anderson, Percy, M.B.E., Gerrard's Cross, Bucks.
Lundie, John, D.Sc., New York City, U.S.A.
O'Brien, Arthur Matthew, F.C.S., Skewen, Glam.
Parker, Charles, Nottingham.
Summers, Daniel Henry, Portsmouth.
Verma, Banwari Lall, Delhi, India.

A paper on "London Traffic" was read by SIR LYNDEN MACASSEY, K.B.E., LL.D., D.Sc. (Secretary to the Royal Commission on London Traffic, 1903-7).

The paper and discussion will be published in a subsequent number of the *Journal*.

EXTRA MEETING.

FRIDAY, APRIL 4th, 1924; HIS EXCELLENCY THE BRAZILIAN AMBASSADOR in the Chair.

A paper on "The Amazon Valley and its Development" was read by MR. GEORGE MACAULAY BOOTH, Director of the Bank of England and of the Booth Steamship Company, Ltd.

The paper and discussion will be printed in a subsequent number of the *Journal*.

A hundred copies of "Modern Brazil," by William Howarth, have been placed at the disposal of the Society by the publishers, Messrs. C. Tinling and Co., Ltd., Liverpool. Fellows of the Society who desire to receive free copies of the book are invited to apply to the Secretary.

COBB LECTURE.

MONDAY EVENING, APRIL 7th, 1924; DR. T. SLATER PRICE, Director of Research, British Photographic Research Association, delivered the third and final lecture of his course on "Certain Fundamental Problems in Photography."

On the motion of the CHAIRMAN, Sir HERBERT JACKSON, K.B.E., F.R.S., a vote of thanks was accorded to DR. SLATER PRICE for his interesting course.

The lectures will be published in the *Journal* during the summer recess.

VISIT TO THE GUILDHALL.

On behalf of the Fellows of the Society and their ladies, the Council have gratefully accepted an invitation from Mr. H. G. Downer, LL.B., a member of the Common Council, to inspect the Guildhall, including the Art Gallery of the Corporation of London, on Thursday, May 8th, at 2.30 p.m.

Sir Alfred George Temple, F.S.A., will act as escort in the Art Gallery and Mr. Deputy Alderton, C.C., in the Council

Chamber, Crypt and other places of interest in the Guildhall.

Fellows desirous of availing themselves of the invitation should inform the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2, on or before May 3rd, mentioning the number of their party.

Those attending are requested to assemble at the main entrance to the Guildhall in King Street, Cheapside, at 2.30 p.m.

PROCEEDINGS OF THE SOCIETY.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 5TH, 1924.

LORD ASKWITH, K.C.B., K.C., D.C.L., (Chairman of the Council), in the Chair.

THE CHAIRMAN said he had to introduce Sir Fabian Ware, Vice-President of the War Graves Commission, of which the Prince of Wales was the President. He had received a letter from the Private Secretary to Mr. Walsh in which he said: "The Secretary of State for War asks me to convey to you his very sincere regret at being unable to accept the kind invitation of the Council of the Royal Society of Arts to attend the lecture by Sir Fabian Ware to-night." The Minister of Transport, Mr. Harry Gosling, who was a member of the Commission, had also personally expressed to him his deep regret that he was prevented from attending the discourse, which he had particularly desired to do. Sir Fabian Ware, with others of the Royal Commission, had devoted six years of strenuous work to the graves of the fallen, known and unknown, in all parts of the world. Many of the audience might have visited the graves of those who were buried within a near distance of this country, at Etaples, Ypres, and particularly the beautiful cemetery at Terlincthum, near Boulogne. Some might have been led there by the various tours which had been organised by the Y.M.C.A. (of whose work he knew something himself, as he was Vice-President of it), by St. Barnabas Hostels, and by other organisations. There were, however, many unknown places of which Sir Fabian Ware would be able to speak that night in that great chain of graves almost girdling the world. Sir Fabian had but lately returned from Gallipoli, and his account would probably be most interesting of what was being done there and of the various alterations in the general designs which might be made there, and also in places so far afield as China and East Africa. He would also be able to speak not only of the graves of known persons, and the artistic architecture or engineering work which had been done upon them, but also of the monuments which had been put up to those who had died as unknown warriors.

The following paper was read:—

BUILDING AND DECORATION OF THE WAR CEMETERIES.

By MAJOR-GENERAL SIR FABIAN WARE, K.C.V.O., K.B.E., C.M.G., C.B.
(Vice-Chairman, Imperial War Graves Commission).

The subject of my lecture is one on which it is extremely difficult to speak in public, and hitherto I have avoided doing so; but I felt when you invited me that the atmosphere provided by your Society and, if an old friend will allow me to say so, the sympathetic guidance which I know that Lord Askwith's chairmanship would ensure, made the undertaking at least possible.

Those of us who literally live and move among these dead cannot discuss their graves with that calm objectivity which art and science bring to bear, for instance, on the tomb of an ancient king, whose racial and religious prejudices have become faint for us in the great distances of time. These dead are of our own blood and race, or of one of the races which are united under the same king; their religion, whether our own or not, found expression in their patience and their sacrifice, which are still very present to our minds. Their religion and their racial characteristics are sacred and living things, and present generations will judge our work, and more particularly that of the architects who have designed the War Cemeteries, by the extent to which we have recognised this. These are difficult things to discuss; it is much easier to try to give expression to them in our work so that they may be intelligible to future generations, and may stir their imaginations and sanctify for them the memory of these dead. Allowing for the inevitable restraint under which he spoke, this is the thought, I think, underlying the words of one of our great architects who was describing to me his impressions when he first visited the cemeteries during the war: "Future generations," he said, "will find it difficult to realise the psychological conditions of those days, when one carried on from day to day at an emotional pitch never likely to be forgotten by those who went through it. The first conclusion I came to was, that whatever we did should speak unmistakeably to posterity of those tremendous days, and should speak in the language of to-day."

But before dealing with the work of the architects, let me say a few words about

that of the engineers, recognising he division of labour between the architect and the engineer, a division which, I imagine, every rue artist deplores, but which is one of the many forms of specialisation brought about by the complications of modern civilisation, and which this country was, I believe, one of the first to impose. The engineer is sometimes regarded as the materialistic partner in this division; whether that is so or not, in this work he has had to bring his most sternly practical qualities to bear on a problem which is certainly of the idealist order; for as you may remember in 1917, at a period in the War when faith alone foretold victory, the representatives of the self-governing Dominions and of all parts of the British Empire met in London as an Imperial War Conference. The Prince of Wales, who had taken an active interest in our work at the front, then addressed to them a memorandum suggesting that they, representing the whole Empire, should make arrangements for the future care of war graves. The Conference unanimously agreed among other things, that, as far as was humanly possible, these graves should be permanent. Perpetuity in sepulture has in the past been a very rare thing, much rarer than is generally realised, assured in any degree to the great of the earth only, most commonly in this country by burial in some historical and sacred monument, of which Westminster Abbey, St. Paul's and other cathedrals immediately occur to us as examples. These dead, the Imperial War Conference held, certainly deserved the honour which had been shown in this way to the former great of the earth, and as they could not be brought in their hundreds of thousands (the British Empire gave over one-million dead to the cause for which she fought) beneath the sacred shelter of existing monuments, structures at least as lasting must be erected at the spots in distant lands where their comrades had buried them. To ensure this lasting quality, to give effect to this ideal of perpetuity, has been the special task of the engineer, with whom rests the last word on structural stability and durability. I shall naturally be speaking this evening a great deal more of the architects than of the engineers, but, believe me, nothing could have surpassed the devotion with which the highest possible mathematical and scientific knowledge has been placed at our disposal, and the invariable response of the engineers to the claims of a great ideal.

Let me give you one of the simplest examples of this. It is only necessary to visit any churchyard in this country to see how the headstones become displaced by time, sometimes leaning in all directions, at others removed and placed against a surrounding wall, the space they occupied being used for new burials or some other purpose. All chance of that had to be prevented in the war cemeteries, and this is what the engineers have done. A trench is dug at the back of each row and a continuous concrete beam is constructed in this. On the upper side of this beam there are sockets into which the headstones are fitted and fixed with cement, and they are thus held as in a vice, permanently immovable. The land for the cemeteries has, as you know, been given in perpetuity in each former allied country by the people of that country at their own cost, following the generous example first set by France in honour of our dead. There is, therefore, no fear that the land will ever be used for any other purpose, but even if that had not been so, the labour and expense which would be incurred in the removal of these headstones and their foundations, would economically prohibit anything of the kind.

You will have observed that the point of view from which I have approached the subject of the building and decoration of the war cemeteries has brought us directly to the graves themselves. And whatever line of thought you take this must inevitably be the result. But before I follow up this line, let me break off for one moment in order to give you some idea of the number and distribution of these graves over the face of the globe. I find that not only the general public, but even those who take a direct interest in the question, have very little conception of this. For instance, quite recently I received a letter from an important organisation asking if they were right in believing that there were several cemeteries with different names in the Ypres area. I think the best way I can bring the facts before you is by means of maps, on which the cemeteries are marked. You see them stretching across France and Belgium in a chain from the English Channel to the Vosges, nearly 1,000 of our War cemeteries in these two countries, in addition to more than 1,500 French Communal

cemeteries and churchyards, in which some of our dead are buried. In Switzerland there is one cemetery at Vevey, where the remains of the British prisoners of war who died in that country have been gathered together. The chain continues across the north of Italy, and there are in that country, together with scattered cemeteries and graveyards, 93 in all. Across Macedonia the chain stretches—here there are 21 cemeteries—down the Gallipoli Peninsula,, where there are 31, to Smyrna, through Syria, where there are two, through Palestine, passing over the Mount of Olives itself—in Palestine there are 40—through Egypt, where there are 5, down Mesopotamia and to East Africa, where there are 400 burial places which it is necessary to concentrate, then the chain extends across the north of India, to China, where there is a cemetery at Tsingtao, and 23 other scattered burial grounds, to Australia and New Zealand, across Canada, and back to the United Kingdom, where there are more than 67,000 graves in some 5,000 churchyards and cemeteries. There are fifty other countries, off the track I have followed, where British War graves have been found. Someone, writing on these graves shortly after the war, truly said that the Empire had thrown a girdle of honour round the world.

You may ask why we have not moved all the small cemeteries into the larger ones. There are several reasons of which I will only mention one. During the war we chose certain authorised sites, where the dead could be buried, some of them close to the trenches; the soldiers were promised that if they brought their dead comrades to these, which they not unfrequently did at the risk of their lives, they would rest there permanently undisturbed.

With that necessary digression let me return to my subject. I said that from whatever point of view you approached it, you were led directly to the graves themselves. This is as it should be. Our work itself would indeed be a lamentable failure if, in designing the cemeteries, the graves had not always been first in our thoughts, if, for instance, the cemeteries were so ornate and elaborate in construction that the graves were hidden or overshadowed by buildings and monuments, and the impression was given at that first glance, which invariably biases our judgment, that they were merely a minor feature in the architectural conception. The vision of peace, with its background of sublime tragedy, proceeds from the graves alone, and if the architectural design is in any way a worthy one, even the casual visitor on entering the gate should first be irresistibly attracted by the rows of headstones; they should invite, and, if necessary, compel his attention. That is certainly the effect that the architectural treatment which has been adopted invariably has on me personally, and on every one with whom I have visited the cemeteries. It is not until you have passed silently before the headstones, reading the inscriptions, eloquent in their very brevity, that you gradually become conscious that each of these groups of dead, whether small or great, (in some there are no more than forty graves, in a few over ten thousand) is a community knit together by bonds of fellowship as in no ordinary resting places of the dead, and instinctively you look around for some symbol of this unity. It is then that you turn to the massive Stone of Remembrance and the Great Cross of Sacrifice.

Before considering these two collective monuments and other buildings which complete the construction, I will, therefore, describe first the headstones which mark the graves (and of which about 180,000 have already been erected to replace the wooden crosses). May I explain at the outset that I am speaking now of the very great majority of cemeteries? Those demanding exceptional treatment, owing to their peculiar situation or the race and religion of those buried in them, I will deal with subsequently.

The headstones are all of the same shape, two feet eight inches high (above the ground), one foot three inches broad, and three inches thick, the top forming a segment of a circle two feet six inches in radius. The size, proportions and upper curve were decided by a special Committee of artists and architects, as from both the æsthetic and practical point of view it was necessary to obtain the best opinion available. For instance, the durability of these stones depends largely on the effectiveness of the curve at the top to throw off the rain in the way least likely to wear the inscription. The curve designed has been found to give the maximum efficiency in this respect. On each headstone is inscribed a reproduction, specially designed for carving on stone, of the badge which the dead soldier wore in his cap. Should the grave be that of

a general or an officer of higher rank, who did not wear his regimental badge, it is nevertheless the one which, by universal desire, is inscribed on his headstone. The name, age, military rank and other distinguishing details are engraved on the upper part of the stone, in the middle a cross or other appropriate religious emblem, (e.g. the six pointed Star of David for a soldier of the Jewish faith) and below this a text or other personal tribute chosen by the relatives. One headstone, which is, alas, too common, is that to the unknown soldier bearing the words "Known unto God."

I am not to-night giving any account of the administrative side of the work, or I would have to draw your attention to the amount of correspondence involved in the making of every headstone, as, of course, the relatives' wishes have to be ascertained with regard to the religious emblem and the personal inscription at the foot of the headstone, and they have also to be asked to check and often to correct the initials and spelling of the name. The manufacture of these headstones is going on in all parts of Great Britain, the output being about 2,000 a week.

To turn now to the collective monuments: ". . . . a carven stone and a stark sword brooding on the bosom of the Cross," as Mr. Kipling described them in his poem on the King's Pilgrimage two years ago. In all the cemeteries there is the Great Cross of Sacrifice, designed by one of our principal architects, Sir Reginald Blomfield. It differs in size to suit the dimensions of the cemetery, the largest being twenty-four feet high, the smallest fourteen. It stands on a great octagonal block (weighing in the largest type about two tons), which rests on three octagonal steps. The shaft and arms are in section in the form of an octagon. The length of the two arms is about one-third of the height of the cross measured from the base of the shaft. The shaft is in one stone from the pedestal block to under the arms. The arms are in one piece of stone fastened by two bronze dowels in to the head of the shaft. The base of the shaft is let into the pedestal block by a six inch stone joggle and a bronze dowel. The shaft tapers from the base to the top of the vertical lines, being set out to a somewhat emphasised entasis.

There is no doubt that the design of this Cross, carried out in white stone, against which the bronze sword stands out in the changing lights, very much as old arms and weapons against a wall, has appealed very strongly to public imagination. Its symbolism, like that of many great artistic creations, is somewhat vague, or rather open to various interpretations; to some the sword is itself the cross and the stonework merely the frame, to others the sword symbolises the offering up in sacrifice of those who perished by the sword, and other interpretations suggest themselves, evidently many, for all who accept the Cross at all seem to have found in it something which responds to their individual feelings. You will see that it is indeed a noble monument, towering with a certain majesty above the headstones.

It was originally the intention of the Commission that each architect should be at liberty to design a special cross suitable in his view to each cemetery, but general opinion was too strong for us, and this design had been adopted wherever possible. We even recently had the design for the cemetery on the Mount of Olives modified, so that this cross should also be erected there. The thoughts which that suggests are better left to the imagination than put into words. As time has gone on the names "Cross of Sacrifice" and "Stone of Remembrance" have attached themselves to the two central monuments; I don't know who originated them, but they have been generally adopted, and undoubtedly express the feelings which each suggests, but it would not be right that this should in any way limit the use to which they are put. For instance, in a service which I attended last Easter in the large cemetery at Lijssenthoek, where 800 relatives had gathered together, Communion was celebrated at the stone, which was used as an altar.

This Stone of Remembrance, designed by Sir Edwin Lutyens, is to be found in all the larger cemeteries. Its dimensions are such as to make it a monument as permanent as any work of man can be. It is a monolith weighing nearly ten tons. Each stone bears the inscription engraven in large letters, "Their name liveth for evermore." I will describe it in Sir Edwin's own words—"Great fair stone of fine proportions, twelve feet in length, lying raised upon three steps, of which the first and third are twice the width of the second. . . . absolute and simple in form, with the greatest possible amount of labour and thought required in its manufacture, in that all its

horizontal surfaces and planes are spherical and parts of parallel spheres, 1801 feet 8 inches in diameter, and all its vertical lines converging upwards to a point some 1801 feet 8 inches above the centre of these spheres."

The æsthetic effect of these two monuments depends on their setting in relation to the levels and surrounding natural features; each cemetery is therefore designed by a member of the Commission's architectural staff on the spot, under the guidance of one of the principal architects, by whom the design is finally approved. That was the system which Sir Frederic Kenyon recommended to the Commission in his report, which has guided us throughout our work. It is a form of collaboration between younger architects and the heads of their profession of which we may hear more in the future.

Personally, I always feel that the most restful effect is obtained where the cemetery contains no other stonework than the headstones and these two monuments, the whole drawn together and softened by trees and shrubs. I will show you examples of this. You will notice that some years must yet pass before the trees are large enough to have their full effect, and what is missing altogether from these photographs is the colour of the flowers, to which the cemeteries owe their chief beauty from early Spring to late Autumn. The horticultural aspect of our work has been dealt with in lectures by Dr. Hill, the Director of Kew Gardens, who has been helping us for the last six years. It certainly deserves a lecture to itself. The skill and devotion of our large staff of gardeners, all of them ex-service men, often with friends buried in the very cemetery they are tending, is beyond all praise. What an opportunity they have! White stones standing in green grass lawns, and these two white monuments for a background. Want of water, every possible variety of soil, sand dunes to be held back and covered with whatever growth they will take, some of the cemeteries in old orchards, others on the bleak hillside, with the worst possible aspect and no shelter from the weather, the natural desire of the Dominions that their own indigenous trees and shrubs should be planted near their graves, these and such considerations have called for many long and patient experiments. But here again the greatest skill and knowledge which the Empire possesses has been placed at our disposal, nurseries have been established which supply everything that is required from existing stock, and this part of the organisation is already beng transformed into the main branch of the permanent maintenance staff. The photographs will give some idea of what has already been achieved, but imagination must supply the colours of the flowers.

FIG. 1.—Ferme Olivier Military Cemetery, Belgium.

There are, however, larger cemeteries, some of them with ten or twelve thousand headstones the effect of which is to give an impression of barrenness, I might almost say desolation, however toned down with foliage and flowers, if they are not counterbalanced by further solid structures in addition to the Cross and the War Stone. In these shelters have been provided, and indeed, owing to the greater number of visitors who may be expected, the seclusion which they afford is very desirable. These give further scope to the architect. You

have the simplest form, a shelter and gateway combined, at Forceville; at Terlincthun, near Boulogne, Mr. Herbert Baker has combined the shelter, to which he has added a Record House, and the War Stone on a broad terrace, the effect, with the Napoleon Column rising above the wood in the background, being very impressive. I wish I could also show you his beautiful treatment of the cemetery of Tyne Cot, on the Passchendaele ridge, where 11,000 soldiers, mostly unknown, lie around German blockhouses, the central one of which forms the base of the Cross of Sacrifice, and on the rising ground behind a shelter and record house are joined by a curved wall, on which are inscribed the names of 20,000 of those who have no known graves. But it is not yet completed. At Boulogne Eastern Cemetery, Mr. Charles Holden has connected the shelter and record house with a stone roof with a cornice supported on four columns. The stone of Remembrance is placed under this roof.

There is one cemetery in France which will be seen by more people than any other; it lies among the sand dunes at Etaples, close to the main line to Paris and the South, and 11,000 of our soldiers are buried here. The design was entrusted to Sir Edwin Lutyens. On the highest sand hill among the fir trees a wide terrace has been built overlooking the whole cemetery, and with a view of the English Channel in the distance, between the two light houses at Le Touquet. Above the centre of the terrace stands the Cross of Sacrifice, and below, on the terrace itself, the Stone of Remembrance. At each end of the terrace are pylons in the form of vaulted shelters, carrying overhead cenotaphs adorned with the flags of the several services. A stepped mound from the terrace gives access to the graves, which stretch in all directions, the headstones

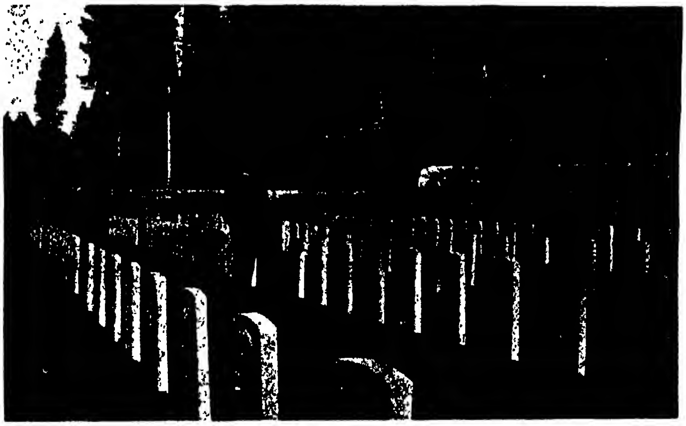

FIG. 2.—Boscon Military Cemetery, Italy.

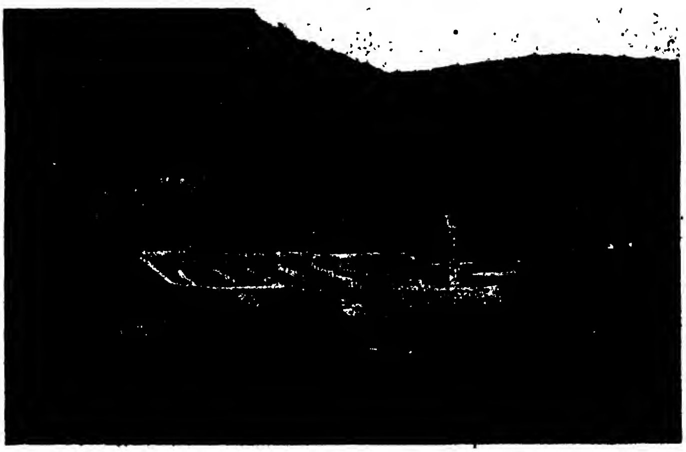

FIG. 3.—Cavalletto Military Cemetery, Italy.

stand in grass, and amidst them are growing trees and shrubs and flowers.

Throughout all these cemeteries you will have observed there are common features which give them their distinctive character. The Cross of Sacrifice stands out distinct in all of them, and as time goes on it is acquiring a special significance and association with the War Graves of the British Empire, so much so, that as I have said, the Commission has insisted on its employment wherever possible. But there are instances, even in mainly Christian cemeteries, where it is obviously unsuitable. This was first found to be so in the mountain cemeteries in Italy. You have seen with what effect Sir Robert Lorimer used it in the Giavera Cemetery in the Italian plains. On the Asiago Plateau, however, 4,000 feet high, covered with snow from October to April, are five small cemeteries, Monte Cavalletto, Granezza, Magnaboschi, lying among the open hills, Boscon and Barenthal in the clearings of a pine forest. These, as you will see from the photographs, are enclosed, according to Sir Robert's design, by walls built thick and strong of local marble, and in each is a massive cross formed of rough blocks of the same stone, sometimes white, sometimes red. There are no paths, but the headstones, of the same type as in France, rise from green sward in which are planted cyclamen, gentian, columbine, and the other exquisite wild flowers of the district, rock plants growing on the walls.

In the advanced cemeteries on the Macedonian front, where the dead lie still guarding the line far from human habitations, Sir Robert Lorimer has replaced the Cross by a Cairn, conical in form, built of rough blocks on a concrete foundation; it is 11 feet 4½ inches in height, and is surmounted by a rough stone cross 10 inches square and 3 feet 10 inches in height. Here, also, he has designed a very striking monument for an Indian cemetery.

On the Gallipoli Peninsula we have had perhaps the hardest task of all. I was visiting the cemeteries there a fortnight ago, and have returned full of admiration for the artistic conception of our principal architect for that area, Sir John Burnet, and of gratitude to our staff for the way they have overcome difficulties which would have beaten all but the most stout-hearted. Here, too, the nature of the work has commanded a peculiar devotion to duty, which those engaged in it, comrades of those who fell there, regard as a matter of course. You will remember what a large part the sanctity of these graves played in the negotiations with the Turks at Lausanne; Australia and New Zealand, at any rate, to whom one third of the dead on the Peninsula belong, being prepared to secure that sanctity at all costs. There are 31 cemeteries, five in the Helles area, south of Achi Baba sixteen stretching in a chain from Suvla

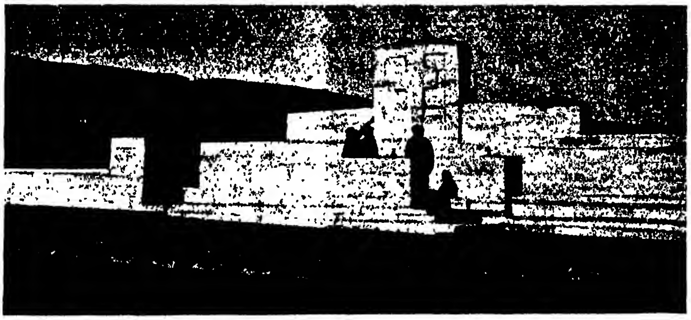

FIG. 4.—V. Beach Cemetery, Gallipoli.

Bay to Anzac Beach. Some of them are on the beaches close to the blue Aegean Sea; others in the Anzac area, are in the sides of deep gullies, or on the ridge from which the Turk was never dislodged, close to his old front line. They are all now in Turkish Territory, from which the Greek population has been "exchanged," so that these in the Helles area are among a Mohammedan population, those to the North in practically uninhabited country. Neither the upright headstones nor the great Cross of Sacrifice, with its bronze sword were suitable for the conditions which will govern their maintenance in the future. The graves are marked by slabs on which are engraved the name, regimental particulars, date of death, a cross or other symbol of the dead man's faith, and an inscription chosen by

the relatives. This slab, which is made in this country and sent out, is fixed and cemented into the top of a large concrete block about two feet of which is below the surface. The cemeteries had all to be built of local stone, the landing of heavy material presenting practically insuperable difficulties; fortunately stone existed of the best quality. The cemeteries are surrounded with great walls of massive rubble masonry, deep stone ditches running along their base. The outstanding feature of the design is a screen wall of ashlar masonry at the upper end of the cemetery, 20 feet to 30 feet in length, and 6 feet to 9 feet in height, according to the size of the cemetery. In the centre of this screen wall, in a curved recess with broad stone steps along its whole length, is a large plain cross in relief, cut into the massive stonework itself. In the larger cemeteries is placed the Stone of Remembrance, similar to that in France, but built up of large blocks cemented together. It was impossible to transport the seven-ton monolith over these roads and up the gullies. In some the screen wall is replaced by a massive pylon on which names of missing are inscribed. In Lone Pine Cemetery, on the summit of the Anzac ridge, is such a pylon, some 50 feet high, with the cross cut on all its four faces.

On this will be inscribed the names of 3,840 Australian and 1007 New Zealand soldiers who fell near by and have no known graves, and of 1,250 men from the two Dominions who died at sea. The view from this monument is one which can never be forgotten by those who have seen it, cemeteries in white stone from Suvla Bay in the distance marking the furthest points reached by our troops. In the Helles area the cemeteries are equally impressive, and what memories their names recall, Pink Farm, Twelve Tree Copse, Lancashire Landing, V. Beach, and, in the Suvla area, Green Hill, with its massive pylon, one of the largest cemeteries on the Peninsula.

It is absolutely impossible for me in one lecture to treat even briefly the cemeteries in the other countries, Palestine, with its largest cemetery on the Mount of Olives, the Cross of Sacrifice rising in the centre, Egypt, Mesopotamia, where Major Warren is our Principal Architect, and East Africa. But I cannot leave the subject without a reference to the commemoration of the missing, of those soldiers who have no known graves and those sailors who have no known graves but the sea. They can have no headstones on their graves, but the Governments of the Empire have decided that they shall not be without their record in stone. It was suggested by some that headstones should be erected to them in the cemeteries, but there was an overwhelming feeling against the false impression as to the existence of a grave which these would ultimately suggest. The participating Governments represented on the Imperial War Graves Commission have not all adopted the same method of commemorating these men. New Zealand, with smaller compact forces remaining together during the war, has records which enable her to commemmorate them in the cemetery near which they each fell. South Africa and Newfoundland are commemorating theirs on national memorials in France. The United Kingdom, Canada, Australia and India are, generally speaking, following a common system, which I will shortly illustrate.

All ships passing in the future in or out of the Dardanelles will sight on the highest ground above Cape Helles a monument rising 100 feet against the sky. On this will be inscribed the names of all the ships and military units which took part in the Gallipoli campaign; on walls around the base are carved the names of 12,000 men of Great Britain and Ireland who fell on the Peninsula, and of 200 Australians who were killed on the Helles area (the rest are commemorated on the Lone Pine Memorial), all of whom have no known graves. The site has been so selected that this monument to our missing dead will be for all time a mark for ships sailing these seas. It is the same height as was the Colossus of Rhodes. It will be completed in the early Autumn. At Port Tewfik, at the Southern entrance to the Suez Canal, is being built the monument to the Indian troops, the religion of many of whom has dictated a different form of burial to that represented by our graves. Sir John Burnet's design is a square obelisk 65 feet in height set on a large stone platform with flanking walls for the inscriptions, terminating with groups of sculpture by Mr. Jagger, each depicting a crouching tiger on guard defending the monument, the one from approach from the canal the other from approach from the sea. In Macedonia the Memorial to the Missing of the Salonika Force has for some time been finished. It forms part of the Memorial to this Force, the cost

of which was borne by a fund subscribed by the troops themselves. The whole has been designed by Sir Robert Lorimer and built by the Commission. It is situated on Colonial Hill, overlooking Lake Doiran, near one of our largest cemeteries. You will see from the photograph that a short distance away from the four corners of the monument, which is 40 feet high, are four piers. Into the sides of these are sunk marble panels, on which the names of the missing are inscribed. In France similar Memorials will be erected, the sites have already been selected, and that at the Menin Gate, Ypres, is now building. On this will be inscribed in stone the names of 60,000 missing Englishmen, Scots, Welsh, Irish, Australian, Canadians, and Indians and Colonials, who fell in the Ypres Salient, but have no known graves. The memorial designed by Sir Reginald Blomfield occupies a position at the town end of the Causeway, across the moat leading to the Menin Road, over which passed, never to return, those who will be commemorated there. It is in the form of an arch or gateway, the main hall

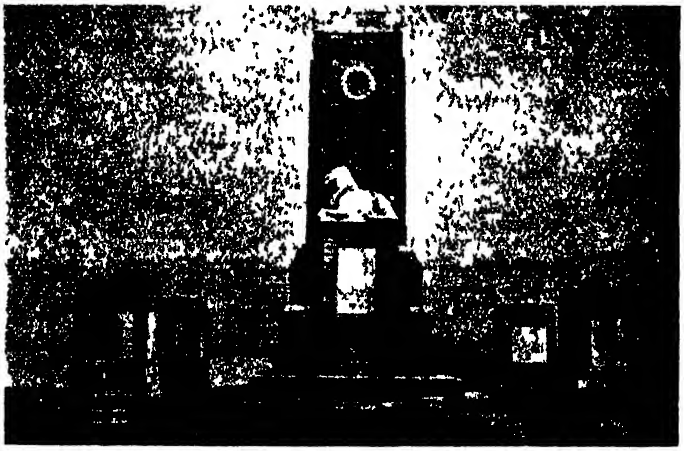

Fig. 5.—Lake Doiran Memorial, Macedonia.

is about 70 feet span by 50 feet in height, and 130 feet in length from end to end. Looking at the arch from outside the old ramparts of which it forms a part, the main structure rises in three great steps, and is surmounted in the centre by the figure of a lion in repose; beneath the lion above the soffit of the arch is this inscription :—

"To the Armies of the British Empire who stood here from 1914-1918, and to those of their dead who have no known graves."

In the same position at the other end of the arch is this inscription :—

"Here are recorded names of officers and men who fell in Ypres Salient, but to whom the fortune of war denied the known and honoured burial given to their comrades in death."

I come last to the memorial that has been most recently completed, that at Chatham, to the dead of the senior service, which will be unveiled by the Prince of Wales on April 26th. The Admiralty appointed a Naval Memorials Committee in 1920, to advise us as to the most suitable form of memorials to the 25,567 ranks and ratings who had lost their lives at sea. The Committee decided on three memorials at the three manning ports, Chatham, Portsmouth and Plymouth. They came to the conclusion that, "It would greatly add to the sentiment and perpetuation of the memorial to associate it with some practical naval purpose. And what could one have to better fulfil both these conditions than a sea-mark or leading-mark near the foreshore? Surely the combination of a Naval Memorial at Portsmouth, with a beacon to guide the ships into their Home Port, and to guide the liberty boats over the Swashway, will appeal to all."

The sites selected were in the Park on the North side of the Hoe at Plymouth, on Southsea Common at Portsmouth, and on the Great Lines at Chatham. The three memorials are similar in design. I will, therefore, show you a sketch of Chatham. The names of the dead are recorded on bronze panels that in front bearing the following inscription :—

"In honour of the Navy and to the abiding memory of these ranks and ratings of this Port who laid down their lives in the defence of the Empire and have no other grave than the sea. 1914-1918."

That on the back gives the single ship actions, and those on the sides general actions at sea and actions with enemy land forces. The total height of the Memorial is about 100 feet. In describing his design, Sir Robert Lorimer says:—

"The crowning feature of the four buttresses which project at the four angles of the base will be a seated figure of a lion.

"The column which rises from this base is treated with extreme simplicity until the top is reached, where at the angles there are bronze figures representing the four winds and projecting from the angles below these figures are to be carved the prows of ships, the crowning feature of the memorial being a golden globe. The figures and globe are intended to symbolise our far-flung Empire." The sculptor is Mr. H. Poole.

Two other Memorials which may be classed with these, I should like to show you; that to the Native East African Troops, designed by Mr. F. A. Stevenson, and the plaques designed by Lt.-Col. H. Carl de Lafontaine being erected in certain Cathedrals in France and Belguim.

I cannot close this very brief sketch of the work of the Imperial War Graves Commission without reminding you that in accordance with the resolution of the Imperial War Conference, 1918, the cost is borne by the respective Governments in proportion to the number of the graves of their dead. The Commission is the first truly Imperial organisation in the sense that it is equally responsible to each of the participating Governments, all of whom through their representatives take an active part in the control of the administration. The work that falls on the Commissioners themselves is by no means light; the full Commission has met once a month during the last six years, and the Finance Committee once a fortnight. That is as it should be, because if these war cemeteries and monuments to the dead are to be in every way worthy of those whom they commemorate, there must be no lavish expenditure. There is every reason to think that when we have completed our work we shall have exceeded neither the estimate of time, nor of money, which was approved by the Imperial Conference, that is, an average expenditure of £10 a grave and ten years. We have not built up an organisation to do the work of construction itself, but have chosen what is on the whole the more economical way of letting out the contracts, when the drawings and designs are prepared, to public tender, and we have every reason to be grateful to the contractors for the way they have done their work.

Before I close, may I ask you once more to follow in your imagination this chain of cemeteries round the world? From France, through Italy, Macedonia, Gallipoli, Syria, to the Mount of Olives; then on to Egypt, Mesopotamia, East Africa, and round again to Great Britain. These cemeteries and memorials have been built in honour of our dead; they are at the same time monuments unique in history to the achievements of the British race and the British Commonwealth of Nations, they are in all parts of the old world, and in that which was unknown to ancient empires and conquerors, and bear a message to future generations as long as the stone of which they are constructed endures. If we ask ourselves what that message will be, I think our pride in the memory of those whom we honour will be lighted up with an unshaken hope in the ultimate triumph of the faith and ideals in which they died, a hope that they may lie for ever there, this silent League of British Nations, their sleep unbroken by the call to arms or the din of war, guarding as they won the peace of the civilised world

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DISCUSSION.

Dr. A. W. Hill, F.R.S., Director of the Royal Botanic Gardens, Kew, remarked that last summer he made a tour round a good many of the cemeteries in France, and he had been most favourably impressed with their remarkably fine condition, both in regard to those which were finished, and those which were still waiting their final completion with the headstones. It was very possible that anyone seeing the cemeteries out in the wilds which were not fitted with their headstones and which had not received any particular architectural treatment, but only gardening attention, might think that in some ways perhaps they were more beautiful because one saw such a wealth of flowers and such an expanse of grass. He was not saying for one moment that the finished work was not essential and most necessary, but one could see, he thought, rather better in the unfinished cemeteries the beauty of the gardening

effects. It was extraordinary what the British gardeners had done in France and Belgium, both in the sandy wastes and in swampy sites. The British gardeners had made there lawns which would be the envy of many people at home. It was a perfect triumph for the British gardener, and it was entirely due to the horticultural officers and the gardening staff who were working in those parts. The same remarks applied equally to Italy. With regard to the point which Sir Fabian had raised as to the desire of the colonies to put in plants representative of the different parts of the Empire from which the fallen had come, that had been a matter of considerable difficulty. When he had been approached on the matter he had done his best to think of suitable plants. The temperate parts of the world had afforded very little difficulty. From Canada, for instance, no difficulty had been experienced with regard to maples which would be hardy in France. They had not relied on maple seed, as they could have done, which had been ripened in this country, but they had written out to the botanical authorities in Canada for seed, and maples from seed ripened in Canada had been raised in France and at Kew. In the same way the South Africans had been anxious to have some representative plant, but there was nothing which could be grown in those cemeteries in France which was typical of South Africa, except annuals. The Red-hot poker (Kniphofia) was about the only good hardy perennial South African plant, but was not very suitable for a cemetery. Some years ago, however, there had been sent out from Kew to South Africa acorns, from which, in South Africa, they had reared large quantities of oak trees. Therefore, it had seemed rather fitting that South Africa should send over acorns from these trees which had originally gone out from England. That had been done, and young oak trees were now being raised in France from those South African acorns. For the Australian cemeteries there happened to be a hardy form of Eucalyptus which it was believed would grow in France, for seed of which we were indebted to Miss Balfour, of Whittingehame; while for the cemeteries where New Zealand soldiers were buried the Daisy Bush (Olearia) and New Zealand Veronicas were being used. An endeavour was being made wherever there were overseas soldiers buried to plant some tree or shrub which was characteristic of the place from which they came.

Sir Frederic G. Kenyon, K.C.B., said he would like to add his testimony to the general effect which the cemeteries produced on the visitor who saw them. He had seen a great number of the cemeteries in France and Belgium, and one could only come away with a sense of great satisfaction and great thankfulness at the success of the work of the Commission. One got in the first instance a sense of order and discipline in those rows of headstones. They suggested almost a battalion on parade; at any rate they carried out the soldierly idea of order and of discipline, and the principle of equality of treatment for all ranks. The cross also impressed the lesson of sacrifice, the sacrifice made by those men for their country. At the same time they were not depressing places; they were made bright by the flowers and the grass, and in that connexion he would like to add his testimony to the admirable work of the horticultural staff—not only their actual work, but the spirit in which they carried out their duties. He had heard no word of complaint anywhere. He had found the men everywhere proud of their work, and only too glad to help visitors to find the graves of which they were in search. The Commission had every right to be proud of their work, and he believed the country and the Empire would always be grateful to them.

The Chairman (Lord Askwith) doubted whether the subject was one for discussion; he would prefer to ask the audience to thank, with acclamation, Sir Fabian Ware for the account which he had given of the architectural and artistic features of the graves. It had required some influence on his own part upon an old friend to cause him, in the midst of his other heavy work and when he was engaged in planning journeys and in arranging the continuous work of his office, to sit down and compose a discourse; but he had put it to Sir Fabian that it was of great importance to let the world know now, through the Society's Journal and through the press, what was being done with regard to the Empire graves. He knew that none could do that with the same delicacy and literary skill as Sir Fabian Ware could command. Sir Fabian had acceded to his request, and the result had been seen that night. He did not think those present would regret having attended. The address must have caused many thoughts to surge through the minds of most of them. He did not wish to examine them too closely, but there were one or two thoughts which must perhaps have occurred to the minds of most people, which had not occurred to them before the lecture. One that had struck him very much had been that all creeds, all colours, all kinds and types of men were being honoured and their names handed down in those memorials. Not only were the monuments put up in France, but they were put up in every country and every continent in the world. They knew not what the fate of those memorials might be 2,000 years hence, when other races, other peoples and other beliefs might hold the world, but at least there would remain in many parts of the world those great monuments, graven with the names of men and graven in languages of different kinds. It was well, he thought, that at the present time the history of the matter should be brought before the country and put upon permanent record, and nobody could have done that better than Sir Fabian. In the name of the audience he thanked him very much for his lecture.

Sir Fabian Ware, in acknowledging the vote, said the subject was an extremely difficult one to talk about, or even to read about; and if it had not been for the atmosphere which there had been

while he was speaking, it would have been impossible for him to have got through the lecture. He desired to thank the audience for their very kind sympathy and help.

The Meeting then terminated.

NOTES ON BOOKS.

International Orthotype. By A. Deane Butcher, London: F. J. Dangerfield. 1s. net.

There are about sixteen vowel sounds in the English language, and as there are only five vowels, each vowel or diphthong must do duty for several sounds. The difficulties to a child learning to spell, or perhaps even more to a foreign student learning to pronounce English, are too well known to be insisted upon here. The combination of letters "ough," for instance, may be pronounced in five or six different ways. How is the child or the foreign student to know which is the right one?

A great many systems have been devised to deal with this problem. The method known as "Simplified Spelling" has a good deal to be said for it, but many people find it hard to reconcile themselves to the printed result; while the drawback of most of the phonetic systems is that the student is apt to be bewildered by the multiplicity of unfamiliar symbols. In "Orthotype" Miss Deane Butcher uses the ordinary vowels, and in addition to these ten simple signs placed over them. The ordinary spelling of the words is thus retained, while the symbols indicate the correct pronunciation. A child who has grasped the meaning of these symbols should have little difficulty in pronouncing correctly a passage of French printed in "Orthotype."

It would not be possible or desirable to pronounce an *ex cathedra* opinion as to value of this system until one had had practical experience of it in teaching young pupils or foreigners, but on the face of it, "Orthotype" appears to be a simple and sane attempt to deal with a difficult problem, and it is to be hoped that educationists will be found willing to give it a fair trial.

COMMERCIAL TEXT-BOOKS.

In connexion with the Society's examinations frequent enquiries are made by teachers and candidates as to suitable text-books on Business Training, Languages, etc. It is, however, a well-established rule of the Society not to recommend any special works in the various subjects comprised in its scheme of commercial examinations, and many candidates are consequently disappointed in their endeavour to obtain advice and guidance in the choice of text-books.

It is true that most publishers possess a reference library for the use of teachers, but this did not meet the want of candidates who hitherto called at the Society's House for such information. It was thought, therefore, that if the leading publishers of commercial text-books would consent to place at the Society's disposal a selected collection of works of this nature, it would be a valuable guide to teachers and students who are searching for suitable text-books.

The leading educational publishers were therefore approached and the response has been so satisfactory that a very complete collection of books has now been assembled and placed in a special section of the Library. Teachers and candidates are cordially invited to consult these books; they will find a wide range of choice of books on every subject of examination and by comparing one work with another can readily ascertain which will aid them best in their studies. This Library is for reference purposes only, and when the appropriate book is found the student is expected to obtain it from the publisher in the ordinary way. Selected books have been supplied by the following publishing houses:—

Messrs. G. Bell & Sons, Ltd.; Blackie & Son, Ltd.; Butterworth & Co.; Cambridge University Press; Arthur Fieldhouse; Gregg Publishing Co.; Librairie Hachette; George G. Harrap and Co., Ltd.; Hirschfield Brothers, Ltd.; Hodder & Stoughton, Ltd.; Jordan and Sons, Ltd.; Longmans, Green & Co.; Macdonald & Evans; Macmillan & Co., Ltd.; A. Munro & Co.; John Murray; Oxford University Press; George Philip & Son, Ltd.; Sir Isaac Pitman & Sons, Ltd.; University of London Press, Ltd.; University Tutorial Press, Ltd.; Effingham Wilson.

PATCHOULI LEAVES AND OIL TRADE OF SINGAPORE.

The export of patchouli leaves and oil is an item of some importance in the Singapore district. From a report by the United States Vice-Consul at Singapore, it appears that of the leaves exported, 90 per cent. are grown in the interior of the northern portion of the island of Sumatra, and are shipped to Singapore for export. The remaining 10 per cent. are grown on the island of Singapore and in the Malay State of Johore. The leaves, which are collected by the natives, are sent down the rivers to small ports on the north-western coast of Sumatra. At these points they are pressed into bales of 280 pounds each and are shipped to Singapore in gunny sacks.

The imports of patchouli leaves into Singapore for the year 1922 amounted to 10,853 piculs (1 picul $=133\frac{1}{3}$ pounds). Upon arrival the baled leaves are sold to exporters. The exports from Singapore for the year 1922 amounted to 6,837 piculs. A total of 4,016 piculs (the difference between the amount of leaves imported and exported) was used for oil production.

The average production of patchouli oil is from 2,000 to 3,000 pounds a month. Most of the leaves exported were destined for the United States, with India and Europe the next best customers.

Patchouli oil is shipped in 20-pound iron drums, packed in sawdust, two to a case. At the present time there are three oil distillers in Singapore, all of whom are Chinese firms whose distilleries are equipped with fairly up-to-date machinery.

SHIPBUILDING ON THE CLYDE IN 1923.

The *Glasgow Chamber of Commerce Journal* quotes some figures relating to shipbuilding on the Clyde last year. There were launched only 122 vessels measuring 175,528 tons, and the marine propelling engines constructed in the district made an aggregate of only 166,956 I.H.P. These figures, compared with 145 vessels of 388,481 tons and 349,329 I.H.P. in 1922—which was itself a very poor year—so that there was a decrease in the twelve months of 21 vessels, 212,953 tons, and 182,373 I.H.P. Less than half the tonnage of 1922 was launched, and much less than half the work was actually done. Most of the tonnage was launched early in the year, and so represented work done in 1922, while the launching tonnage fell off during the summer and autumn until remarkably low figures were reached. This was explained mainly by the lock-out of iron-workers, but to some extent also by the lack of demand for new vessels. How poor the year really was may be understood best, however, when the output of normal years is recalled. The average of the decade before the war was about half a million tons per annum, and the highest point reached was in 1913, when 370 vessels of 756,976 tons were launched on the river, and machinery of 1,111,440 I.H.P. was manufactured. Not since 1886, when what was even then considered the very poor total of 166 vessels of 172,440 tons was launched, was the output of the Clyde so low as in 1923. Last year the river went back for more than a generation, and reached a level which represented less than one-third of the ships of its best year, less than one-fourth of the tonnage, and not much more than one-seventh of the horse-power.

It is, however, satisfactory to learn that shipbuilding prospects improved considerably near the end of the year, and are now better than they were all through 1921, 1922, and the first eleven months of 1923. There is a very general belief that the worst of the depression in shipping is past, and that there will soon be more profitable employment for general, cargo-carrying tonnage. There are now comparatively few vessels laid up, and owners are inquiring frequently for prices of new ships. A considerable number of orders have been placed, but these are almost wholly for vessels of special types—railway steamers, for example, and harbour service craft—and for motor-ships. There are now under construction on the Clyde 119 vessels of 528,914 tons. Of these, 74 vessels of 326,564 tons are at or above Dumbarton and at the Ayrshire ports; and 45 vessels of 202,350 tons in Greenock and Port-Glasgow. The total compares with 96 vessels of 468,754 tons three months ago, and 83 vessels of 504,724 tons a year ago, so that there has been a fairly definite recovery in the trade. It is difficult to say how much of the work on hand represents vessels delayed by the ship-yard lock-out, but it seems clear that there would have been more work if there had been no dispute. The total under construction is still low—much lower than the average of the twenty years previous to 1923—and it is far short of the 267 vessels of 1,345,864 on hand in March, 1921. It is, however, enough to be going on with if trade conditions are such that orders are received within the next few months to an extent greater than the vessels completed. If this is the case, shipbuilding and marine engineering, and all other West of Scotland trades, will have a much better year than they had in 1923.

The relatively greater decrease in engineering than in shipbuilding is explained by the stoppage of warship construction. Not one naval vessel was launched on the river, and not one set of naval propelling engines. In every pre-war year within recent times there were a considerable number of high-powered naval vessels, while in several of the war years there were so many that the horse-power of the district was enormously higher than that of 1913. These were abnormal years, and cannot be taken into account when trade fluctuations are being considered. The engine-shop work of 1923 was all for mercantile vessels of comparatively low power, but some of it was of exceptional interest. Only three installations of geared-turbine machinery were constructed, but eight sea-going motor ships were supplied with engines, and arrangements were made for the construction at Glasgow of large Diesel engines of the new double-acting type. One set of this type—the first made in Great Britain or Ireland—has been completed at Whiteinch to a design which is new, and is wholly Clyde in conception and workmanship, while others of the Copenhagen design are being constructed at Glasgow. Poor, therefore, though the output of the year was, it represented technical progress of a very definite kind.

HYDRO-ELECTRIC DEVELOPMENT IN NEW ZEALAND.

With reference to the note on potential water power in New Zealand published in the *Journal* of 11th January, some interesting details regarding the development of hydro-electric power in the Dominion during the financial year ended 31st March last are given in the Report on the Economic and Commercial conditions in New Zealand by H.M. Trade Commissioner.

The total expenditure during the financial year was £450,247. The Lake Coleridge power house has been brought up to the full capacity of the existing tunnel by the installation of two additional generators of 3,000 kw. each, making the total power installed 12,000 kw. The load has grown rapidly, and has already reached 10,500 kw., and it has, therefore, been decided to proceed at once with further extensions which will necessitate a second tunnel and intake works. The proposed extensions will consist of two units each of 7,500 kw. with provision for a third unit to be added when necessary. Transmission lines have been completed to Ashburton and Timaru.

The Hora Hora power-house has been in operation throughout the year, the existing plant 6,300 kw. is overloaded and demand is increasing in the

Waikato. The Auckland Electric Power Board is also negotiating for a supply from Hora Hora in advance of the supply from Arapuni, which will not be available before 1928. An extension of two units each of 2,000 kw. has been put in hand, and the transmission line to Auckland is under construction.

No work has yet been done in the main plant at Waikaremoana, but as a small supply was urgently wanted at Wairoa the two exciter sets were installed and have been giving service since December, 1922. No statement has yet been made as to when work on the main plant will be commenced.

The Mangahao plant is making substantial progress, the tunnels and headworks are well in hand, the power-house is under construction, and installation of the machinery was hoped to be begun in November. The Minister of Public Works has stated that he hopes to have the plant ready to operate about next June. Transmission lines to Wellington, Marton, Dannevirke, and Masterton are under construction, and surveys are being made for lines to Napier and Wanganui.

It is proposed to proceed at once with the installation of three units of 15,000 kw. each at Arapuni.

Dunedin City is extending the Waipori Falls station by the addition of a 3,000-kw. unit, and is making provision for the ultimate installation of three more such units. The Southland Power Board is pushing on the Monowai scheme of two 2,000 kw. units, with provision for extension by four additional units. The New Plymouth Borough has plans in hand for a station of 4,500 kw. on the Waiwakaiho River, and the Taranaki Power Board proposes to construct a small station of 1,500 kw. at Tariki.

Several smaller power stations are in hand, and preliminary investigations have been made of sources of power for Otago, Marlborough, Nelson and Westland.

Altogether the Public Works Department are planning to spend well over a million pounds per year on hydro-electric power development and transmission during the next six or eight years.

SOUTH AFRICAN DRIED FRUIT AND PINEAPPLE INDUSTRIES.

In the course of his Report on the Economic Conditions in South Africa, H.M. Senior Trade Commissioner in the Union states that the dried fruit industry is slowly establishing itself on a sound basis. There is a growing tendency on the part of farmers to recognise the need for supporting central grading and packing establishments, and with these in full operation there is a very sound outlook for the industry. With all the necessary fruits growing to perfection it is only a matter of applying correct up-to-date methods to enter the world's markets with every assurance of success.

The western districts of the Cape Province are, by means of their climatic conditions, generally looked upon as being the home of soft fruits and hence the centre of the industry. Thus favoured and having easy access to the best shipping facilities offered in the country they are in a very strong position. The development of the irrigated areas of the Eastern Province will result, however, in the entry of rivals of no mean order for—given water—there are large blocks of land in that area which will produce excellent fruit. It is most probable that big developments in producing fruit for drying will take place in the near future.

As regards pineapples, it appears that despite the large production the position of this fruit is disappointing, and unless the present efforts to grapple with the question of disposal meet with success, large areas under cultivation will prove a failure. The pineapple of the country, though small, is of excellent flavour and readily wins appreciation when known. If sound arrival oversea could be ensured, the quality of the fruit would soon establish a market. The main handicap to development has been the irregular condition in which so many consignments have opened up.

Taking the fruit industry generally, while it is recognised that it is a luxury trade, there is no question that its outlook is sound, and all that is needed is continual pressure in every direction which will tend to better the condition on arrival and the selling life of the fruit in European markets, and the full exploitation of those markets by advertising and thorough distribution.

GENERAL NOTES.

Fourth International Conference on Soil Science.—The Fourth International Conference on Soil Science will be held in Rome, from May 12th to 19th. The first was held in 1909 in Budapest, the second in 1911 in Stockholm, and the third in 1922 in Prague. The Italian Minister of National Economy, Prof. Corbino, has promised to be the honorary chairman. The Conference will be held at the International Institute of Agriculture in Rome.

Mining Operations in the Rand.—Some remarkable figures are quoted by the *African World* regarding the magnitude of the excavated work done by the mining industry of the Rand, which is equal to a distance ranging from the Cape of Good Hope to the Equator. The approximate mileage of underground excavation, that is to say, main shaft sinking, main drives, cross-cuts, and other development achieved on the Witwatersrand since production commenced in 1887 up to date, has been 4,000 miles, which would suffice to drive a tunnel from Cape Town to Stanleyville, the equatorial capital of the Belgian Congo, according to an official calculation, which has been circulated by the Industrial News Service. Up to the end of last year, the total mileage of developments on the Rand has been approximately 2,893 miles, and as the mines are carrying about 70,000 ft. of development per month, or, say, 13½ miles per month, this means that the total development to

date has just been about 3,000 miles. This figure and the comparisons as to distance expressed above will enable one in some measure to realise the vast amount of developing operations that have been carried out, and the figures quoted, it may be remarked, are only for development, and do not take into account excavations which have to be made in respect of stoping or mining the actual ore.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at 8 o'clock.

April 30.—Brigadier-General Sir Henry Maybury, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "The London Dock District and its Roads." Harry Gosling, C.H., M.P., Minister of Transport, will preside.

May 5 (Monday).—T. Thorne Baker, "Photography in Industry, Science and Medicine."

May 7.—J. Robinson, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation." Admiral of the Fleet Sir Henry Jackson, G.C.B., K.C.V.O., F.R.S., will preside.

May 14.—

May 21.—(Trueman Wood Lecture.) Sir William J. Pope, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, "The Outlook in Chemistry."

May 28.—Mrs. Arthur McGarth (Rosita Forbes), "The Position of the Arabs in Art and Literature." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Indian Section.

Friday afternoons, at 4.30 o'clock:—

May 2.—Jocelyn F. Thorpe, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India."

Date to be hereafter announced:—

Bhupendra Nath Basu, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

Dominions and Colonies Section.

Tuesday, May 27, at 4.30 o'clock.—C. Gilbert Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

Wednesday, June 4, at 4.30 o'clock.—The Rt. Hon. Sir Frederick Lugard, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates."

Monday, June 16, at 4.30 o'clock.—C. V. Corless, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, April 14 .. British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. D. F. Slathowwer, "Modern Dutch Architecture."

Geographical Society, Lowther Lodge, Kensington Gore, S.W., 5 p.m. Mr. D. Brunt, "Climatic Continentality and Oceanity."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 7 p.m. (Informal Meeting.) Mr. J. R. Bedford, "Some Idiosyncrasies of Electrical Manufacturers."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 7 p.m. (Graduate Section.) Mr. A. H. Fuller, "Mechanical Refrigeration for the Small User."

At the Chamber of Commerce, New Street, Birmingham, 6.45 p.m. Dr. L. Aitchison, "Light Alloys for Pistons and Connecting Rods."

East India Association, at the Carpenters' Hall, Throgmorton Avenue, E.C., 3.30 p.m. Mr. A. L. Howard, "The Forests and Timbers of Burma."

Brewing, Institute of, at the Engineers' Club, 39, Coventry Street, W.C., 7.30 p.m. Mr. W. A. Riley, "Steam and Super-Heated Steam."

Tuesday, April 15 .. Statistical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.15 p.m.

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m.

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Mr. R. N. Salaman, "An Analysis of Jewish Types."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Lieut.-Commander R. E. Rendall, "One Exposure Tri-Colour Cameras."

Transport, Institute of, at the Institution of Electrical Engineers, Victoria Embankment, W.C., 5.30 p.m. Mr. A. J. Brickwell, "The Rating of Railways and Docks."

Mechanical Engineers, Institution of, Railway Hotel, Coventry, 7 p.m. Dr. L. Aitchison, "Light Alloys for Pistons and Connecting Rods."

Zoological Society, Regent's Park, N.W., 5.30 p.m. (1) The Secretary, "Report on the Additions made to the Society's Menagerie during the month of March, 1924." (2) Mr. Guy C. Robson, "On the Cephalopoda obtained in South African Waters by Dr. J. D. F. Gilchrist, in 1920-1921." (3) Mr. Basanta Kumar Das, "On the Intra-Renal Course of the so-called 'Renal-Portal' Veins in some Common Indian Birds."

Wednesday, April 16 .. Transport, Institute of, Manchester. Mr. A. J. Lyddon, "Road Construction."

Mechanical Engineers, Institution of, Star and Garter Hotel, Wolverhampton, 7.30 p.m. Dr. L. Aitchison, "Light Alloys for Pistons and Connecting Rods."

Thursday, April 18 .. China Society, at the School of Oriental Studies, Finsbury Circus, E.C., 5 p.m. Rev. E. Morgan, "An Ancient Philosopher's View of the Perfect Life."

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FRIDAY, APRIL 18, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

TRUEMAN WOOD LECTURE.

In consequence of illness, PROFESSOR C. VERNON BOYS, F.R.S., will be unable to deliver the Trueman Wood Lecture on "Calorimetry," which he had arranged to give on WEDNESDAY, MAY 21st. His place will be taken by SIR WILLIAM J. POPE, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, who has chosen as his subject "The Outlook in Chemistry."

EIGHTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 9th, 1924; SIR FRANK DYSON, LL.D., F.R.S., Astronomer Royal, in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Fabini, H. V., Richmond, Surrey.
Gothard, H. A. S., Bickley, Kent.
Martynik, Jan, Gemsa, Egypt.
Sandell, H. W., North Shields.

The following candidates were duly elected Fellows of the Society :—

Eedy, Arthur Malcolm, Sydney, Australia.
Muir, James, London.
Rothfeld, Otto, I.C.S., London.

A paper on "The Free Pendulum" was read by MR. FRANK HOPE-JONES, M.I.E.E., Vice-Chairman, British Horological Institute.

The paper and discussion will be published in a subsequent number of the *Journal.*

VISIT TO THE GUILDHALL.

On behalf of the Fellows of the Society and their ladies, the Council have gratefully accepted an invitation from Mr. H. G. Downer, LL.B., a member of the Common Council, to inspect the Guildhall, including the Art Gallery of the Corporation of London, on Thursday, May 8th, at 2.30 p.m.

Sir Alfred George Temple, F.S.A., will act as escort in the Art Gallery, and Mr. Deputy Alderton, C.C., in the Council Chamber, Crypt and other places of interest in the Guildhall.

Fellows desirous of availing themselves of the invitation should inform the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2, on or before May 3rd, mentioning the number of their party. No tickets are necessary.

Those attending are requested to assemble at the main entrance to the Guildhall in King Street, Cheapside, at 2.30 p.m.

PROCEEDINGS OF THE SOCIETY.

FIFTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 19TH, 1924.

LORD CLINTON (Forestry Commissioner) in the Chair.

THE CHAIRMAN, in introducing the author, said Mr. Robinson was a member of the Forestry Commission, and, in addition, was the advisor to that Commission upon all technical matters. Much of the information contained in the paper was the result of Mr. Robinson's personal observation whilst in Canada last Autumn representing the Forestry Commission at the Imperial Forestry Conference. That was a Conference which was of very great importance. It took place periodically and gathered together a great deal of useful information, not the least of which was as to what were the actual resources of timber, not only of the Empire, but of the whole globe. A telegram had been received from Sir William Schlich, whose name was very well known among all foresters as the pioneer of forestry in this country, to the following effect: "Sorry heavy cold cannot come. Congratulate Robinson on complete paper. Could not have added anything but praise." He (the Chairman) could assure the audience that that might be regarded as very high praise indeed.

The following paper was read :—

THE FORESTS AND TIMBER SUPPLY OF NORTH AMERICA.

By R. L. Robinson,
Forestry Commissioner.

The information which I have the pleasure of placing before the Society has been compiled from a number of sources. The British Empire Forestry Conference which was held in Canada last summer afforded unrivalled opportunities for investigating the forest position in Canada. When it was ended, Lord Lovat, the Chairman of the Forestry Commission, Mr. Fraser Story and I visited different parts of the United States forest regions, while Dr. Borthwick inspected the Queen Charlotte Islands. The chief parts of the Continent for which we have no first-hand information are Alaska and Mexico. Our visit to the United States synchronised with considerable activity in the forestry world. A Committee of the Senate was engaged in investigating the whole position, and we had unusual opportunities of obtaining data from that source and through the Officers whom Colonel Greeley, Head of the United States Forest Service, placed at our disposal. The most important of recent literature on the subject of my paper, exclusive of statements presented to the Empire Forestry Conference, is a book entitled "The Forest Resources of the World," by Zon and Sparhawk.

Importance of North American Forests.

It will clear the way if I state at once that the timber supply question in North America centres mainly around what is happening in the United States. That great country steadily increased its population from under 40 million in 1870 to over 105 million in 1920, while its industrial development during the 20th century has far outstripped that of any other nation. The forests have played an extremely important part in this development. Passing from the early colonial days, when timber was the chief commodity of exchange against the manufactured products of Europe, the abundance of cheap supplies of timber rendered possible the rapid construction of houses (over 90% of the houses of North America are made of wood), and the construction of a vast system of railways. Timber, in fact, took the place, to a large extent, of the more durable materials used in Europe. More recently wood, when manufactured into paper, has played its part in advancing American civilisation: the consumption of paper in the United States is approximately 150 lbs. per capita or 8 million tons, of which 90% comes out of the forests.

Main Features of North America.

For convenience I am taking North America to mean the whole Continent and Islands as far south as, and including Mexico, but excluding the West Indies. The range in latitude is from well within the tropics to well within the Arctic Circle. The total land area is approximately 5,188 million acres, of which 1,903 million acres comprise the United States, 2,387 million acres Canada and 493 million acres Mexico. The most striking topographical feature of the Continent is the great mountain system, which can be described collectively as the Rocky Mountains, running close to and roughly in the same general direction as the Western Coast line, with but few breaks from Alaska through British Columbia, the States of Washington, Oregon, California, Idaho, Montana, Wyoming, Utah, New Mexico and Arizona, and Mexico to Central America. The system comprises numerous mountain ranges and plateaux which have important reactions on climate and hence on timber growth. East of the mountains lies the great central plain which runs without any very notable interruptions, save the Canadian Lakes, from the mouth of the Mississippi to the Arctic Ocean. East again of the Central Plain the Appalachian system of mountains runs north-east from the States of Georgia and Alabama to Pennsylvania, and continues with interruptions into Maine. The broad strip between this system and the Atlantic calls for no special comment.

The North and North-East of the Continent is hilly country which has been severely ground down by ice action, a land of innumerable lakes, streams and waterfalls.

Forest Regions.

Over such a large range of conditions the number of tree species is naturally great, greater in fact than one would expect by comparison with Europe. The number of commercial species of trees in the United States alone is upwards of one hundred, and these combine to form very many more forest types and sub-types. It is impossible within the limits of my remarks to describe types, and I must therefore confine my descriptive remarks to a brief survey of the main forest regions, a procedure which,

though quite unsatisfactory from a forestry point of view, has distinct advantages as regards timber supply and utilisation.

1. The Northern Coniferous Forest stretches in a great belt, 300-400 miles wide, from Labrador, north of the prairies, to Alaska. Newfoundland may conveniently be included in this region. The chief species are white spruce (*Picea Canadensis*) on the better soils, and black spruce (*Picea mariana*), in the swamps; locally, balsam (*Abies balsamea*) tamarack (*Larixl aricina*) jack pine (*P. Banksiana*) white pine (*P. Strobus*) and red pine (*P. resinosa*) occur. The area has been extensively burned, and in the brulées birch and aspen take the place of conifers, excepting jack pine. As the Arctic Circle is approached the growth becomes stunted, and timber of commercial size is confined to the watercourses.

2. The Great Lakes—St. Lawrence region marks the best development of the white pine, which is associated with red pine. It has been the scene of extensive lumbering in Canada since the earliest times The original character of these forests has been greatly altered by logging and fire; hardwoods, spruce, jack pine and balsam have largely replaced the white pine.

3. The North-Eastern Forests of the Canadian Maritime Provinces and New England States. The most important species are the red spruce (*P. rubra*), white spruce and balsam fir, associated with jack pine, tamarack and black spruce. Considerable areas of hardwoods (maple, beech and birch), either pure or in mixture with white pine and hemlock (*Tsuga Canadensis*) also occur.

4. The United States Central and Southern Hardwoods formed originally a vast forest of extraordinary value. In the valley of the Mississippi and its tributaries, and in the Southern Appalachian Mountains, occur those species (oak, ash, hickory, walnut, yellow poplar) which have become standard hardwoods almost the world over, as well as many other species, such as chestnut, of great local utility. In the river bottoms of the Southern States occur red gum (*Liquidambar styraciflua*), *Nyssa* or cotton gum. The forests are not exclusively hardwoods, since species from the Northern forests, such as white pine, stretch down into the Appalachians, while cypress (*Taxodium distichum*) is an important species in the swamps. The pines also invade the hardwood areas on the South.

5. In the Southern Pine Region, the forests consist chiefly of yellow pines, viz.: long leaf (*P. palustris*), loblolly (*P. taeda*), short leaf (*P. echinata*), and slash pine (*P. Caribaea*). The hardwoods of the central region also come into mixture with the pines, but are then relatively unimportant.

6. The Rocky Mountains Region. The composition of the forests varies greatly with latitude and elevation. In the North, spruces (white and Englemann's) predominate, but are replaced on burned areas by lodge pole pine (*P. Murrayana*). From the south of British Columbia southwards other important trees such as yellow pine (*P. ponderosa*), Western larch (*L. occidentalis*), white fir (*Abies concolor*) come in. There are also in the wetter and lower belts forests resembling very closely the Pacific coast forests. The distribution of forest throughout the region is uneven, and towards the South the forest areas are greatly broken up by treeless stretches of plateau and arid country.

7. The Pacific Coast Forests are probably the most interesting coniferous forests in the world, whether they are considered from the point of view of variety of species, rapidity of growth or dimensions of individual trees. They are particularly interesting to British foresters since two of the most important trees—Douglas fir (*Pseudotsuga Douglasii*) and Sitka spruce (*P. sitchensis*), grow with equal rapidity in this country.

In the North the commercial forests of Alaska consist of a very narrow strip of Sitka spruce with a small proportion of Western hemlock (*Tsuga heterophylla*). In the Queen Charlotte Islands Sitka spruce is still the principal tree, and there reaches its best development. Further south it gives pride of place, however, to Douglas fir and red cedar (*Thuja gigantea*), with which are associated locally other useful species such as hemlock and western white pine (*P. monticola*). The coastal belt runs south in a strip rarely more than 50 miles wide, but broadens out to about 150 miles in Washington. To the East of the Cascades, yellow pine comes in, and there are extensive stands of that species and western white pine. North of San Francisco lies the interesting and valuable redwood belt (*Sequoia sempervirens*), with stands of timber

containing 50,000 cubic feet per acre and numerous individual trees upwards of 300 feet high and 15 feet in diameter.

The Sierra Nevadas are also heavily forested with yellow pine (*P. ponderosa*), sugar pine (*P. Lambertiana*), and several silver firs. Here also grow the "big trees" (*Sequoia gigantea*), of imposing dimensions.

8. THE MEXICAN FORESTS can be roughly divided into three main types. There are, first, the tropical forests running up from sea level to about 2,500 feet, consisting of very numerous species, of which mahogany, cedar (*Cedrela odorata*) and dyewood are common articles of commerce. This zone is succeeded by a transition forest containing oak, cherry and other hardwoods, with a sprinkling of pines at higher elevations. The most extensive and important forests are the coniferous forests of the mountains, which are predominantly pine, both white and yellow.

EXTENT OF FORESTS.

The total area of North America which is covered with forest or wood of some sort or another is of the order of 1,500 million acres, of which some 770 million acres are in Canada and Newfoundland; 550 million acres are in the United States; 70-150 million acres are in Alaska, and 74 million acres are in Mexico. It is impossible to be precise with these figures, since large areas which are believed to be mainly forest have scarcely been explored, much less mapped. It would appear from these figures that the area of forest in North America is about double that in Europe. From the point of view of timber supply, however, very great deductions have to be made from the total areas by reason of inaccessibility or the character and size of the trees. It is estimated that, of the Canadian forest area, only 292 million acres out of 770 million carry merchantable timber, and only 154 million acres saw-timber. The United States total of 550 million acres comprises 138 million acres of virgin forest, 250 million acres which have been cut over and culled but are reproducing timber, 81 million acres which have been logged, burnt and left barren, while 80 million acres are open forest of scrub trees. The commercially useful timber in Alaska appears to be confined to the two National Forests of approximately 20 million acres, while 49 million acres in Mexico have been classed as timber forest. From these figures a total area of effective forest of 750 million acres is obtained. This is equivalent to approximately 6 acres *per capita*.

STAND OF TIMBER.

The quantity of timber standing in the forests of North America has been estimated at different times by the various forest services. It would appear to be between 1,100,000 and 1,200,000 million cubic feet, of which 65% to 70% is in the United States and 20% in Canada.

THE DRAIN ON THE FORESTS.

In addition to the wood which is removed from the forests for use, viz. for manufacture into lumber, pulp and paper and for fuel, enormous quantities are destroyed annually by fire and the ravages of insects and fungi. Estimates have also been made, as for the volume of standing timber, of the quantities of wood removed annually from the forest by all these agencies. The latest figures compiled by Zon from estimates made by the different forest services indicate that the total volume is in the neighbourhood of 32,000 million cubic feet annually. On this basis, if there were no growth at all, and all the wood were accessible, it would all be used up in approximately 35 years. Put in another way, one can say that if the rate of growth averaged 3% all over and the timber were all accessible, the consumption could go on indefinitely. As will be seen later, the latter assumption appears to be very wide of the mark. Of the total amount of wood removed from the forest, approximately 28,000 million cubic feet are cut for use, while 4,000 million are destroyed by fire, insects and fungi. Of the cut, the United States forests furnish 24,300 million cubic feet or 87% and the Canadian forests 2,616 million cubic feet or less than 10%. In the United States rather more than 50% is softwood, and in Canada more than 90%. Fuel wood accounts for 43% of the United States cut and 30% of the Canadian. For pulp there are cut annually in the United States forests 4½ million cords, and in the Canadian 4 million cords, equivalent in all to 1,000 million cubic feet of standing timber. Vast as the pulp and paper industry is it consumes only from 3% to 4% of the total cut.

As regards losses from fire, insects and fungi, any estimate must necessarily be subject to considerable margins of error. Forest fires burn over, on the average, about 10 million acres per annum. The Eastern

forests in particular have suffered severely from insects and fungi. The larch saw-fly practically wiped out the mature larch some 30 to 40 years ago, a recent attack of spruce budworm has killed huge quantities of balsam and spruce, while the chestnut disease, introduced from Asia, is proceeding to wipe out one of the most valuable species in the United States. In all probability, therefore, the estimate of 4,000 million cubic feet losses which I have stated above, is not seriously over-stated. It represents from six to seven times the total amount of wood used annually in the United Kingdom.

Trade in Timber and Primary Wood Products.

Of the total volume cut in the forests some 570 million cubic feet have been exported per annum in post war years from the country of origin. The corresponding import amounts to approximately 400 million cubic feet, so that on balance North America appears to be exporting to the extent of about 170 million cubic feet. For various reasons, which I need not detail, it is impossible to be precise. The figure quoted, though great in itself, is relatively insignificant when compared with the total consumption.

External Trade.

Not only Britain but Western Europe generally in the past have made great demands on North America for both special and general utility timbers, while the tropical and Southern American countries have been almost wholly dependent on the North for building timbers. From the Pacific coast shipments of Oregon pine have been made for many years to Australia and the East. With the opening of the Panama Canal, the Pacific timbers have come in increasing amounts to the Eastern American markets and to Europe. The trade with Australia, Japan and the East generally is also expanding.

Internal Trade.

There is a great and rapidly growing movement of wood products within the Continent itself. Broadly, this takes the form of the transport of softwoods from the West and South to the industrial regions of the East, of softwood building timbers from the West to the Prairies, of hardwoods and large-sized structural timbers from the South to Canada, and of pulp wood and small dimension softwoods from Canada to the Eastern pulp mills and manufacturing district of the United States.

United States.

Exports of lumber reached their maximum in 1913 at approximately 285 million cubic feet, but declined in 1920 to approximately 165 million cubic feet. The United Kingdom and Canada are the best customers in this trade. On the average of the 5 years, 1909-1913, the former took nearly 40 million cubic feet, valued at nearly £4 million, as well as wood manufactures, valued at just over £1 million. In 1922, the comparative figures were 22 million cubic feet, £4.9 million and £1 million. On the average of the 5 years, 1910-1914, Canada took 53 million cubic feet, and in 1915-1919, 25 million cubic feet. The total export of timber fell in the second 5 years period to 50% of the first. After the United Kingdom, Canada and the West Indies, South America and Australasia have been in order, the biggest consumers. For the last year or two the West Indies have been the largest customers. The most striking feature of the United States export trade is the decline of trade with Europe since the war.

The United States imports consist of hardwoods and softwood constructional timber, and cordwood, of which the last two come almost entirely from Canada. In 1920, the total import of timber was approximately 150 million cubic feet, of which the hardwoods, amounting to about 7 million cubic feet, came chiefly from the West Indies, Central and Southern America.

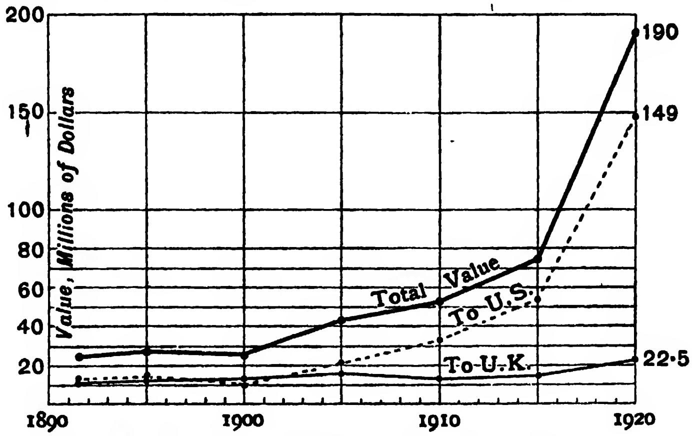
Canada.

Exports of wood and timber on the average of the years 1919-1922, amounted to approximately 295 million cubic feet. The most considerable single item was 1,105,000 cords of pulp wood, all of which went to the United States.

In addition to wood and timber, there were also exported annually, manufactured wood valued at \$3.2 million, wood pulp, \$52.3 million, and paper \$74.3 million, the total exports being valued at \$226.7 million as against \$31.2 million imports. Imports were made up of unmanufactured wood and timber, \$13.0 million; manufactured wood, \$6.6 million; wood pulp, \$1.6 million; and

paper, $10.0 million. The imports of timber consisted chiefly of hardwoods and sleepers.

The United Kingdom and the United States are the chief competitors for Canadian forest produce, but the latter are rapidly displacing the former. The diagram below illustrates this movement very clearly.



Canadian Exports of Wood, Wood Products and Paper.

As in the United States, the West is developing its export trade in timber; British Columbian water-borne exports increased from upwards of 9 million cubic feet in 1919 to nearly 23 million cubic feet in 1922, in which year the United States took nearly 7 million cubic feet, Japan 6 million, Australia and New Zealand 5 million.

Newfoundland.

The bulk of the timber cut in the island is consumed locally, the items of export in 1922 being pulp 20,000 tons, and paper 35,000 tons, which were sent to the United Kingdom.

Mexico.

The Gulf forests of Mexico for a very long time exported important quantities of mahogany, cedar, logwood and dyewood. Zon estimates the total average pre-war exports at about 5 million cubic feet, of which rather more than 50% went to the United States and rather less than 50% to Great Britain.

In 1913, Mexico sent nearly 5 million cubic feet of sawed lumber to the United States. On the other hand, there is a considerable import of softwoods, including railway sleepers, amounting to perhaps 15 million cubic feet from the United States.

Forest Exploitation.

I will now ask you to follow me in a closer enquiry into the effect of all this on the forests themselves.

In the United States, the procedure in forest exploitation has been to concentrate on one, or at most two regions at a time. The capital invested in sawmilling plant is comparatively small, and the sawmiller has been able to follow up the retreating forest. For this and other reasons, it has paid him best to work with large and often wasteful units. The pulp and paper mills which entail far greater initial outlay in plant and buildings are less mobile, and, as we shall see later, failure to maintain the forest in a productive state is leading to difficulties.

The North-East States.

The story of modern forest exploitation begins with the North-Eastern States, which until about 1870 provided the bulk of the lumber supply of the whole of the United States. There were originally over 108 million acres of forest from which most of the original pine, spruce and hemlock have been cut. These States can now supply only 30% of their own requirements of timber. On the other hand, a vast pulp and paper industry has been set up with a capital investment of $565 million, producing 53% of all the paper manufactured in the United States. There is a heavy import of pulp wood from Canada to keep the industry going.

The Lake States.

From about 1870 onwards, these States became the leading timber-producing area,

vast quantities of white and red pine being shipped away. Hemlock and hardwoods are now the chief timbers, and Michigan, Wisconsin and Minnesota depend on outside sources for 47% of their consumption of timber.

The pulp and paper industry consumes over 1,100,000 cords of wood per annum, and the problem of securing a continuous supply is very difficult. There are in these States 20 million acres of denuded and burnt over land which are practically barren.

The Southern Pine Region.

After the Civil War exploitation began on a considerable scale, but it was only when the Lake States production began to decline, about 1890, that production on the grand scale started, reaching a maximum of 1,400,000,000 cubic feet, or 8,500,000 standards in 1909. The cut is declining, and in 15-20 years the virgin stands will be worked out. Our enquiries point to the lower figure, and one of the largest milling companies is preparing to turn over to pulp-production within that period. Production by modern mills is extremely rapid; a single mill which was visited consuming per diem 60 acres of mature forest, and turning out 500 standards of timber. As in the Lake States, enormous damage has been done by fire, and there are upwards of 30 million acres of denuded land in this region. When the Southern pine has been cut out, some substitute will have to be found for pitch pine, which is the standard timber for heavy construction work in many parts of the world. Intimately allied with timber supply is the Naval Stores industry, which has an annual output exceeding 40 million dollars. Three-quarters of the world's supply of turpentine and rosin is produced here.

Central and Southern Hardwood Region.

The original forest area amounted to 339 million acres, but has now been reduced to about one-third (124 million). Much of the forest in the Mississippi and tributary valleys was on rich agricultural land, and has been cleared for farming. The forests in the Southern Appalachians have been severely culled, and chestnut blight has done a great deal of damage. There is, however, considerable second growth. The last great reserves of virgin hardwood forest are in the delta of the Mississippi. This region uses 46% of the total lumber consumption of the United States, and has to import 60% of its requirements.

The Rocky Mountain Region.

There is a great area of virgin coniferous forest (some 38 million acres), in addition to some 25 million acres which has been burned (chiefly) or logged. The forests are difficult of access for topographical reasons, and the region at present actually imports 50% of its lumber.

The Pacific Coast Region.

This region contains the last accessible reserve of virgin softwood in the United States. There are still some 40 million acres of virgin forest, the bulk of which, together with some 15 million acres of cutover land, will never be used for agriculture. The region produces about 31% of the United States timber cut, and production is rapidly increasing as the Eastern and Southern forests are worked out.

The position with regard to the supply of wood and timber in the United States may be summed up thus: Softwood saw-timber is being cut 8½ times as fast as it is growing, hardwood saw-timber 3½ times as fast. Including all kinds of wood, one quarter of the current cut is replaced by growth and three-quarters are a drain on capital. The consuming industries are situated for the most part in the east and north-east, where the forests have been pretty well depleted. Local supplies are quite inadequate and the deficit has, therefore, to be brought from the Southern and Western forests and from Canada. In 1920, the cost of transport alone amounted to $250,000,000, the amount moved being one and two-third million carloads, and the average haul 485 miles. Timber is now being shipped from the Pacific to the Atlantic Coast at a freight cost of $30 to $32 per standard, and railed from West to East at $50 per standard. The pulp mills of the North-Eastern States find it increasingly difficult to work to capacity, and in some cases have to transport cordwood several hundred miles by rail; the average cost at the mill being $19 per cord.

Canada.

The Dominion Forestry Branch (Craig), estimates that on 60% to 65% of the forest land the timber of commercial size has been cut or burned—chiefly burned. In the East,

the accessible forests have been culled, first for large white pine, and secondly for large spruce. The result is that one has to get far from the beaten track to see large trees. From the published figures there appears to be a distinct tendency for the production of timber to decline, and, as in the United States, for the centre of production to shift westwards—to British Columbia. On the other hand, the Eastern pulp and paper production has increased by leaps and bounds. In 1908 there were cut 1,325,000 cords of pulp wood, of which 483,000 cords were used in Canada; in 1920, 4,025,000 cords were cut, and 2,777,000 cords were used in Canada.

ALASKA.

The production of timber is slight, but in the last year the National Forests have been opened up to pulpwood operations, and it is anticipated that in due course a great pulp and paper industry will be built up on a permanent basis.

MEXICO.

The Mexican forests have not yet received the systematic attention of large scale operators. Large mills were erected some years ago in the North but were destroyed in one of the periodic revolutions.

FORESTRY IN NORTH AMERICA.

Forestry in North America has been a plant of slow growth. With so vast an area of forest it has been difficult to bring public opinion to realise that the timber supplies are not inexhaustible and that action is necessary.

In the United States the forests were disposed of to individuals at an early stage. Of late years large areas have been re-acquired by the Federal Government, largely during the Presidency of Mr. Roosevelt, and by the individual States. Of the total area 98 million acres are now in public ownership, 221 million acres belong to timber companies and other commercial organisations, and 150 million acres are in small parcels (woodlots) attached to farms. The public forests include nearly 78 million acres of National Forests and Parks, which are, however, to a great extent at the headwaters of navigable streams in the Rockies (mainly), and elsewhere, and consequently are not easily accessible. They are being gradually opened up and placed under systematic management. The different States own about 7 million acres.

In view of the devastation which private ownership has brought about in the States the Federal Government is retaining the commercial forest areas in Alaska, and proposes working them in such a way as to ensure continuous production.

In Canada and Newfoundland the forests for the most part have not been alienated from the State. The practice, mainly, has been to retain the freehold, and to lease the timber for exploitation by commercial companies. In this respect Canada is more fortunately situated than the United States, since the Governments retain the power to enforce rational forest management whenever that course becomes economically possible. In all, about 157 million acres have been set aside as Dominion and Provincial Reserves and Parks, but at present very little has been done in them to ensure continuous supplies of timber.

The conditions in Mexico during the last few years have not been such as to encourage the practice of forestry.

Generally the immediate forestry problem in North America is to secure adequate protection against fire. If this could be secured, natural regeneration, which is good in most regions, would go far to restock the forests as they are cut. But natural regeneration, to be really successful, requires regulating, so that the most useful species may be secured, and as a rule some measure of assistance in the form of planting. These are the first stages in systematic silviculture, and so far they have received very little attention.

The area which is being planted per annum in North America is under 40,000 acres, which is not double the amount done in Great Britain. Keeping in view the vast areas which can be restocked with useful species only by planting, the effort is quite inadequate. There is, however, a growing interest in the subject, not only on the part of Governments, but also pulp and lumber companies. It is realised in fact that prices of forest products are advancing to, if they have not already reached, the point where they will repay the cost of production.

A word must also be said as to the extensive research work which is being carried on in the United States and Canada on timber growing and utilisation. The results are not only of immediate practical utility, but will also prove of great value when silviculture comes into its own.

The Future.

It seems clear that there must be considerable stringency in supplies of forest products in the United States within the next twenty or thirty years. Consumption *per capita* of timber over the last 50 years is fairly accurately known. In 1850 it was under 20 cubic feet, but increased at a fairly steady rate until 1909, when it reached 40 cubic feet. Thereafter it fell rapidly to 26 cubic feet. This figure is to be compared with a United Kingdom consumption of 9 cubic feet *per capita* in 1922, and 12 cubic feet on the average of the 5 pre-war years 1909-13. The total *per capita* consumption of wood in the United States, however, is 228 cubic feet, so that if effective economies are to be made, they must be applied mainly to such products as fuel wood and round timber and in the conversion of round timber to lumber. In the last there is, indeed, ample scope for improvement. One can forecast with reasonable certainty that while *per capita* consumption will continue to decrease and population to increase, the total consumption will not be easily reduced until prices go much higher than at present. It seems fairly clear also that the North American continent will absorb all the forest products it can produce, and the considerable excess of exports over imports of softwoods and hardwoods will shrink to negligible proportions or be replaced by an excess of imports over exports. It is quite possible, in fact, that the Eastern States may become competitors with the United Kingdom and Western Europe generally for the softwoods of Northern Europe. This might become a serious matter for the United Kingdom, since the permanent exportable margin from N. Europe is not capable of very great expansion. As regards hardwoods, increasing demands will no doubt be made on tropical forests.

It is clear also that the world's supply of really large softwood timber will be practically worked out within the time I have mentioned, when the accessible virgin forests in North America will mostly have been cut over.

Ultimately North America, like Europe, and indeed the rest of the world, will have to rely on the products of cultivated forests. We are now at the beginning of that stage in the history of the North American forests. The Report of the States Senatorial Committee, to which I referred in opening, indicates that vigorous action may be taken in the United States. The Silvicultural Committee of the Empire Forestry Conference pointed out also that the time is ripe for action in Canada.

Conclusion.

Apart from the absorbing interest attaching to the use which the North American continent has made of its primeval forest resources, my subject has very practical bearings on the United Kingdom. We ought, in the first place, to be paying more attention to the forests in our tropical colonies, which can probably provide efficient substitutes for hardwoods at present obtained from America. In the second place, one of our sources of timber supplies is failing. We can therefore go forward with our forest policy in full confidence that it will be a good national investment. That at least is the main conclusion which the Forestry Commissioners draw from their study of the Forests and Timber Supply of North America.

DISCUSSION.

The Chairman (Lord Clinton), in opening the discussion, said the author had put before the audience a large number of facts and figures which were of the most important nature, to a few of which he himself might draw particular attention. The author spoke of the forests of the North American continent in terms of millions of acres, or hundreds of miles. That did not convey very much to one's mind, but the important fact which the author had shown was that only a comparatively small amount of that great forest area was in any way merchantable or marketable. Out of the 770 million acres of timber in Canada, for instance, only 154 million acres, or one-fifth, were ever likely to reach the market. Presuming the same sort of figures applied to the timber area in the whole of the North American continent, it was quite certain that with the enormous amount which was now consumed by that continent itself, and by those countries which imported from it, that area could not for very long stand the strain. That idea was enforced by the statement that in the United States alone they were so eating into the capital of their timber that the amount of produce removed from their forests was no less than eight-and-a-half times their growth. Statements were heard about single mills in the United States having a daily consumption of 60 acres of timber. Under those circumstances it was certainly not surprising to find that many of those States, like the North Eastern States and the Lake States, which at one time comprised the great timber belts of the southern half of North America, were no longer self-supporting and had to import the bulk

of the timber which they used. It was stated also that in the Southern pine belt, the period of life in the virgin forests was not more than 25 to 30 years. In spite of that enormous drain upon the capital of the timber supply, apparently very little was being done to make it good. The young growth was too often burnt over, and the amount of artificial planting done was so small throughout that great area that it was barely equal to about double what was done in this small country of Great Britain. In addition to great consumption, there was fire and pestilence, so it was not surprising that those forests were rapidly disappeariug. It was almost surprising that trees were able to be grown at all. He would like to ask the author one question. The author estimated that, while the total amount of timber used would undoubtedly increase in the future, he apparently was of opinion that the amount of timber used per head was likely to decrease. For the last half a century everybody had been somewhat surprised at the fact that, in spite of the very large number of substitutes for timber, the amount used per head had always been increasing. It had increased right up to the date of the outbreak of the war. It was quite true that since that date it had decreased very largely, both in the States and in the United Kingdom, and probably throughout the world, but that was due, one would imagine, much more to external conditions, such as bad trade, collapse of the exchanges, and other things, than to any economy which had been effected, or which was likely to be effected in the ordinary use of timber throughout the world. It might affect estimates very largely indeed if it were possible to show that the economies which could be employed in the use of timber might eventually so far affect the supply that the life of these great forests might be longer than anybody at the moment anticipated.

The effect of the drain on the timber forests of the world upon this country naturally had to be considered. It was upon timber that industries throughout the world had been started, and it was upon timber that they very largely flourished. It was of desperate importance to us to form some real idea of what was to be done here or elsewhere when the forests of the world were exhausted, or when that much earlier period arrived when the nations and countries which had those forests would require the whole production for their own internal uses. It all pointed to the fact, which he desired to emphasize, that, in this country, at all events, the State itself was bound to look forward and see what could be done for the future of its industries before it was too late. It was perfectly clear to him personally, as a forester, and should be clear, he thought, to those who had charge of the affairs of this country, that in order to put the future in as good a position as the present, it was essential that the State should continue its forestry operations on a much larger scale than it was doing at present.

The soft wood supply was a great difficulty. He was not certain that the hard wood supply would not be in the near future one of greater difficulty. The oak supply of this country was essential for the needs of a great number of our industries. It could hardly be expected that private individuals would continue planting a tree which, owing to the great length of its rotation, could scarcely turn out to be in any sense profitable. But the State itself should take a very much longer view. As a generation to-day, we were depending upon supplies of timber which had been planted by our predecessors a hundred or a hundred-and-fifty years ago. Without that supply we could not at this moment carry on a great deal of the work which we were now doing. There had been little or no planting for the last 70 years. We were enjoying the goods which a past generation had supplied for us. It was not of much importance to us to-day whether that past generation had made money or lost money over the production of timber. In the same way the State should look forward, and although the Forestry Commission might not be able to show commercially that the planting of oak timber was in any sense likely to be a commercial proposition, yet as we ourselves were enjoying the fruits of what a former generation had done for us, we in our turn ought also to supply future generations with the necessities of their own industrial world. He did hope that the many important matters which the author had stated in his paper would be brought before those who were responsible at the present moment for the finances of the country, and that they would take some guidance from what had been said, and adopt the necessary steps to ensure the future of the timber supply to this country.

He proposed a most hearty vote of thanks to the author for his paper.

LIEUT.-COLONEL F. D. W. DRUMMOND, C.B.E., in seconding the vote of thanks, said the paper certainly gave one grave cause for reflection. The outlook was exceedingly gloomy, and impressed one with the great necessity there was for the Departments concerned urging, not only upon foreign countries with whom we traded in forestry products, but also upon our Colonies, the great importance of quickly putting their houses in order and doing something to reinstate the ghastly destruction by fire and felling which was going on throughout the great timber areas of North America, Canada and our Colonies generally without replacement. The Forestry Commission was doing magnificent work, and the people of this country could not be too grateful to them for it. It was to be hoped that the Government would be impressed with the work of that Commission and further encourage it with sufficient finances to enable it to do more extensive work.

MR. LOREN L. BROWN, Timber Commissioner, British Columbia, said there was another gloomy point which he could add, and that was in regard to the timber coming from the region of the Pacific coast. When those forests were cut down there would never again be timber like it. The world would not be able to wait two or three hundred

years for such trees to grow again, and people would have to satisfy themselves with a very low grade of soft wood lumber.

MR. J. S. CORBETT, Secretary English and Empire Forestry Association, said the author had referred to the consumption of timber for pulp. It had occurred to him to wonder whether, if those areas in the United States, Newfoundland and Canada were left, they would eventually be able to grow merchantable timber. He did not know what the species were which were usually converted into pulp wood, but there did seem to be a possibility of salving some of that timber if other material could be found within the Empire (and he believed there was other material within the Empire) which could take the place of the timber which was at present being used for pulp.

COLONEL G. L. COURTHOPE, M.P., desired to say how pleased he was that the Royal Society of Arts had opened its doors to such a paper as that which had been given that evening, because he had been very much perturbed of late at the lack of interest, and at the lack even of attempts to excite interest, in the very serious problem of the timber supply of the future. The author had clearly satisfied everybody that in a very few years Europe must not expect to get any timber from North America at all. The story, however, did not end there. Those who were familiar with the report of the British Empire Forestry Conference held in Canada last Autumn, would probably recollect a very interesting paper by Prof. Fraser Storey, in which he gave a table of figures of the production and consumption of softwood timber in Europe, from which it appeared that the rate of consumption exceeded the rate of production by something like three and a half thousand million cubic feet a year. At that rate of consumption there would be no softwood left at all at the end of something like 70 years. What did that mean? It was easy to say "We shall arrive at a stage before very long when countries will get frightened and begin to cultivate their forests and reduce waste and effect economies, and so on, and things will get better"; but it took generations after a country began to cultivate its forests before it could supply the commercial demands for timber, and during the hiatus of two or three generations the world was going to suffer acutely owing to a shortage of commercial timber. The time was not very far distant when not only commercial softwood would become very expensive, but also unobtainable. Directly exporting countries realised the danger of the present rate of exhaustion they would place restrictions upon exports, and we, in this country, to whom imported timber was more important than to any other country in the world, would suffer. It might easily be found within the next generation or two that commercial softwoods, which we were accustomed to regard not only as an essential of our existence, but as an inexhaustible essential, would be unobtainable at any figure which we could afford to pay. It behoved the professional organisations to do all they could to rouse public opinion on the matter so that remedial measures might be taken at the earliest possible date. The British Empire possessed great forests as to the contents of which hardly anything was known at present, and it was quite time that we began to learn a great deal more about what was there, the uses to which they could be put and to what extent some of the tropical hardwoods, which were hardly ever used now for commercial purposes, could be used in substitution for the commercial softwoods upon which we were now accustomed to rely. There were many other lines of investigation and research which ought to be started at once. All that was necessary was to rouse public opinion, and he hoped the author's paper would mark a red letter day in that direction.

MR. D. MCVICAR (Western Australia) said they, in Western Australia, had started a very intense propaganda on the subject of timber supply within the last two or three years. They were trying to indicate to the people there that the forests did not belong to the present Government, or to any Government, but to the people. Necessarily, if the forests belonged to the people they should be protected by the people themselves. Until 1918 Western Australia had no Forest Act; all revenue derived from forests went direct into consolidated revenue. From 1919 three-fifths of the net revenue was put back into the forests. Australia had been cutting her forests for the last 40 or 50 years. In Western Australia to-day they were cutting at the rate of 800,000 loads of timber. The forests were making 250,000, so one could see how they were encroaching on capital. They were finding it very hard indeed to get a sympathetic hearing, and also to get money. Forests could not be grown without money; and unless that money was obtained timber would be short. In Western Australia there were 640,000,000 acres of country and 350,000 people. If that territory was peopled, Western Australia would require all its own timber. The Forest Department there was doing its best to regenerate the forests. The silvicultural work had only been started since 1919. It was, however, going ahead and they hoped to do better. They wished their parent Association in this country all luck in its work.

The vote of thanks was then put and carried unanimously.

MR. ROBINSON, in reply, said there were two points to which he had been asked to reply. The first was the Chairman's point that the consumption of timber tended to increase per capita. That had undoubtedly been the case in this country where it had increased three-fold in the last 70 years. Our consumption per capita, however, was in the neighbourhood of about 12 or 13 cubic feet. In the United States it was now in the neighbourhood of 26 cubic feet. If we could live on 12 cubic feet the possibilities were that the United States people could live on less than 26. The actual course

of lumber consumption per capita in the United States had gone in the following way. In 1850 it amounted to 20 cubic feet per head. It grew steadily, until, in 1909 it was 40 cubic feet. Then it had fallen until at the present time it was 26 cubic feet. Actually the great saving to be made was in regard to waste.

Mr. Corbett asked the question whether the pulp wood being cut in Canada could grow into merchantable—by which he presumed Mr. Corbett meant saw-timber. Personally, he thought quite a lot of it could, but it would not. The white spruce easily got to be a saw log size. The black spruce was a doubtful tree which rarely got to much more than 8 or 9 inches in diameter. As to whether the bulk of the Canadian pulp would ever be allowed to grow into saw timber he thought the answer was pretty clear.

THE CHAIRMAN, in closing the meeting, said he thought Mr. Robinson's paper would be a great addition to the literature upon the subject of North American forests. He might also be permitted to thank the Royal Society of Arts for inviting Mr. Robinson to give his lecture, thus showing their interest in the very important matter of forestry.

The meeting then terminated.

CORRESPONDENCE.

NEW USES FOR RUBBER.

Owing to an alleged obscurity in my definition of the desirable size of rubber blocks for road paving in the *Journal* of April 4th (page 340), I think it advisable, to add these particulars:—Taking, for example, the thickness of the rubber block as 3 inches, the width should be 6 inches and the length 9 inches.

D. R. BROADBENT,
A.M.I.E.E., A.M.I.M.E.

GENERAL SHORTREDE'S LOGARITHM TABLES.

Our senior partner, a Fellow of your Society, has drawn our attention to the remarks made by Mr. A. R. Hinks, C.B.E., M.A., F.R.S., Secretary of the Royal Geographical Society, and reported in your *Journal* of February 8th, page 204, with respect to the Logarithm Tables of the late General Shortrede, which we publish.

As the information given by Mr. Hinks was quite new to us, we communicated with Mrs. Shortrede, the daughter-in-law of the late author, and her son, Lieut.-Colonel Edward G. Cheke, F.R.G.S., has supplied us with the following very interesting note :—

"General (then Major) R. Shortrede calculated his Logarithm Tables 'in the sublime solitude of the Western Ghats' during his spare moments, while he was carrying on that section of the Trigonometrical Survey of India. I have *never heard any mention* of the '18-inch Theodolite being dropped off a tower'—and even if it were a fact I do not quite see how that would cause him to spend a considerable portion of his time in the Ghats. On his return from India, General Shortrede took up his residence at Blackheath, where he went through all his Logarithm Tables again—without finding one single inaccuracy. General Shortrede always laid claim to have been the first person to determine the *height* of Everest—and thereby established it to be the highest peak of the Himalayas. The statement that the height of Everest was determined in the Survey Offices in Calcutta is a pure myth."

As General Shortrede's Logarithm Tables continue to be widely used, you may think with us that the correction and information given now is of sufficient historic importance to justify the insertion of our letter in your journal.

CHARLES & EDWIN LAYTON.

NOTES ON BOOKS.

THE YEARBOOK OF THE UNIVERSITIES OF THE EMPIRE, 1924. Edited by W. H. Dawson and published for the Universities Bureau of the British Empire. London: G. Bell and Sons, Ltd. 7*s.* 6*d.* net.

There are now 67 universities in the British Empire, and their united calendars contain about 50,000 pages. Probably no library except that of the Universities Bureau contains them all: hence the usefulness of a volume like this in which such information is extracted as is likely to be of use to members of universities and colleges, government departments, clubs, schoolmasters and the public generally. A full list is given of the teaching staff of each university and brief accounts of the equipment in libraries, museums, laboratories, etc., and of the degrees, diplomas and certificates which it confers, while further sections deal with fees, scholarships, numbers of students, etc. A full index adds to the value of the volume.

We have made numerous tests of the accuracy of the information contained in the book and have found it invariably reliable.

ADVISORY ART COMMITTEES:

A SUGGESTION TO CITIES, TOWNS AND RURAL AREAS.

There have been, in recent years, encouraging signs of increased interest on the part of the general public in questions relating to the preservation and increase of the general artistic and natural amenities of towns and rural areas. Expression of this view is also shown in a desire to preserve the fine works of past ages, while the universal approval with which the recent appointment of the Fine Arts Commission has been received, and the formation of similar Committees of taste

which had preceded it in more than one provincial centre, clearly shows the increasing interest which is being taken in civic development generally, and the desire for its treatment from the æsthetic as well as from the purely utilitarian standpoint.

The Royal Institute of British Architects is anxious to encourage these tendencies, and invites the co-operation of those actively interested to secure that in the march of progress the claims of beauty are not forgotten. As a means to this end it suggests the formation of an Advisory Art Committee in towns and rural districts, with the object of affording advice in a consultative capacity in all matters concerning the amenities of the district, including questions relating to the preservation of old buildings, the lay-out of new streets, open spaces, cemeteries, designs for proposed new public buildings, bridges, monuments or memorials, fountains, public means of lighting, fences, public conveniences, or other structures to be erected upon land belonging to or under the control of the Local Authority, that may be referred to the Committee, or as to which it may desire to give advice.

The constitution of the Committee which is suggested will vary according to local circumstances, and will differ in urban and rural areas. In many towns Civic Associations already exist, and the influence which these or similar organisations possess may suitably be employed to foster the establishment of an Advisory Art Committee. In smaller localities the machinery of the Local Ratepayers' Association might be used. For example, there already exists in one London district such a Committee of the Ratepayers' Association, which is doing most useful work in safeguarding the amenities of its own district.

The findings of the Committee should be in the nature of recommendations only, and it may be necessary that all such matters as may be considered by it should be treated in strict confidence, and not be divulged except by agreement with the Local Authority concerned.

It is essential that such a Committee as is suggested should be representative of real artistic competence and judgment (though not necessarily of the purely professional kind), and that its members should be persons whose opinions are likely to command public respect. The cultivation and preservation of harmonious relations with the Local Authority is of the greatest importance, and the best means by which this end may be attained requires the most careful consideration.

The Royal Institute of British Architects, while not presuming to dictate upon the question of the constitution of Advisory Art Committees, will be glad to offer advice and such information on the subject as they possess, if required to do so.

NATIVE INDUSTRIES OF TUNISIA.

The following particulars of the native industries of Tunisia are taken from the recent report on the trade of the Regency by the Acting British Consul-General at Tunis:—

POTTERY.—Both in Tunis and in the inland districts quantities of unglazed, somewhat rough pottery are made, principally for local domestic use. A certain quantity, however, of the better varieties is exported.

This pottery is very picturesque but extremely fragile, so that the consumption of it is greater than would be the case otherwise. In the native inns and drinking houses stacks of shallow drinking bowls are to be seen, and it is to be presumed that the customers break a good many, and so keep the potters busy.

In the hot weather there is a great demand for the deep native porous pitchers in which, owing to the rapid evaporation, water keeps surprisingly cool.

This kind of pottery is very cheap; a drinking bowl costs only the equivalent of an English penny.

A charming glazed and coloured pottery is also made, of far higher quality, principally at Nabeul. This is very artistic and is much sought after by tourists, who, however, being unversed in oriental methods, are made to pay at least double the current price. In fact, it is usually cheaper to buy the Nabeul pottery from the large general stores in Tunis at retail prices than at the factory at Nabeul at so called "semi-wholesale" prices. A visit to the factories is, however, most interesting.

An increasing amount of this pottery is exported. The total exports of Tunisian pottery of all kinds in 1922 amounted to about 437 tons.

LEATHER GOODS.—In Tunis and other centres, notably Kairouan, the holy city, a certain quantity of very cunningly-worked fancy leather goods are made by hand, including bags of all sizes, both plain and worked with silver thread, purses, wallets, belts, cushions and mats, all of very oriental design. The output is limited, and no attempt appears to be made to increase it by methods of division of labour or other more modern devices and labour-saving instruments. This is typical of the Arab mind, but it is probable that the goods are all the more artistic and curious.

Although these leather goods can be bought at many of the larger stores, the more interesting kinds, as well as the standard patterns, can be purchased to greater advantage in the "Souks," namely, the native shops of the Arab quarters. This is a somewhat lengthy process thanks to the need for bargaining.

Owing to the difficulty of obtaining these goods in sufficiently large quantities, the exports are relatively small, the total for 1922 being 44 tons.

NATIVE STUFFS, CARPETS, BLANKETS, FEZ CAPS.—The stuffs comprise highly-coloured shawls and sashes of oriental pattern, now somewhat in demand in Paris owing to the fashion for "barbaric" effects in ladies' wear. The local prices appear very moderate to English and American purses. Exports amounted in 1922 to some 30 tons.

Carpets are made principally at Kairouan on hand looms in the native houses. The best wool is used, and the carpets are very heavy and durable. The demand for export is increasing, and as the

output remains the same, prices have in consequence risen considerably. Some 18 tons of carpets were exported in 1922.

The output of homespun woollen blankets is very much greater, the principal centre being Gabes; 155 tons were exported in 1922.

With regard to fez caps, it is interesting to note that part of the material, namely, the straw shell or framework, comes largely from Czecho-Slovakia to be worked up in Tunis. Over 20 tons of fez caps were exported in 1922.

GENERAL NOTES.

Cabuya Fibre in Ecuador.—According to the report by H.M Chargé d'Affaires at Quito on the economic conditions in Ecuador, the Cabuya fibre is found abundantly in the mountain region of that country, and grows wild even in the most infertile zones. It is used locally to some extent for the manufacture of carpets, sacks, rugs and rope. Two small installations have been erected at Riobamba for the manufacture of ropes and sacks similar to those made of jute. If this produce were properly developed Ecuador could transform it into one of its chief industries, and provide from its own sources the number of sacks required for her industries, which amounts to approximately two millions.

Water-Power of the St. Lawrence River.—The Canadian Government has under consideration a project for the development and control of the water power of the St. Lawrence River. This involves the construction, with the co-operation of the United States, of a dam control works and development plant at Morrisburg, Ontario, at a cost of from 75,000,000 to 80,000,000 dollars. The installation would produce some 350,000 h.p. for Ontario and a like amount for the State of New York. It is suggested that approximately 15,000,000 dollars, which would be Ontario's share of the cost, should be borne by the Federal Government in compensation for the provision of water control facilities by the province.

Trade in the Gold Coast.—According to statistics published in the "Gold Coast Gazette" Trade Supplement, the total value of the Colony's imports for the first half of last year was £4,748,796, of which £3,411,419 was from the United Kingdom, £116,102 from other parts of the British Empire, and £1,221,275 from foreign countries, the principal contributors being the United States, Holland, and Germany. The total value of the export trade for the same period was £5,582,043, of which £1,899,370 went to the United Kingdom, £196,589 to other parts of British West Africa, and £3,486,084 to foreign countries, principally the United States, Holland, Germany, and France.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at 8 o'clock.

April 30.—Brigadier-General Sir Henry Maybury, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "The London Dock District and its Roads." Harry Gosling, C.H., M.P., Minister of Transport, will preside.

May 5 (Monday).—T. Thorne Baker, "Photography in Industry, Science and Medicine."

May 7.—J. Robinson, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation." Admiral of the Fleet Sir Henry Jackson, G.C.B., K.C.V.O., F.R.S., will preside.

May 14.—F. C. Ingrams, President of the London Fur Trade Association, "Furs and the Fur Trade."

May 21.—(Trueman Wood Lecture.) Sir William J. Pope, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, "The Outlook in Chemistry."

May 28 (at 4.30 p.m.)—Mrs. Arthur McGrath (Rosita Forbes), "The Position of the Arabs in Art and Literature." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Indian Section.

Friday afternoons, at 4.30 o'clock:—

May 2.—Jocelyn F. Thorpe, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India." Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., will preside.

Date to be hereafter announced:—

Bhupendra Nath Basu, M.A., Vice-Chancellor of Calcutta University, "The Vedantic Philosophy of the Hindus."

Dominions and Colonies Section.

Tuesday, May 27, at 4.30 o'clock.—C. Gilbert Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

Wednesday, June 4, at 4.30 o'clock.—The Rt. Hon. Sir Frederick Lugard, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates."

Monday, June 16, at 4.30 o'clock.—C. V. Corless, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada."

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FRIDAY, APRIL 25, 1924. 5 JUN. 1924

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2).

NOTICES.

NEXT WEEK.

WEDNESDAY, APRIL 30TH, at 8 p.m. (Ordinary Meeting). BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director General of Roads, Ministry of Transport, "The London Dock District and its Roads." HARRY GOSLING, C.H., M.P., Minister of Transport, will preside.

FRIDAY, MAY 2ND, at 4.30 p.m. (Indian Section.) PROFESSOR JOCELYN F. THORPE. C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., "Chemical Research in India." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Rector, Imperial College of Science and Technology, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

COUNCIL.

A meeting of the Council was held on Monday, April 14th. Present:—

Lord Askwith, K.C.B., K.C., D.C.L. (in the Chair); Lord Blyth; Mr. A. Chaston Chapman, F.R.S.; Sir William H. Davison K.B.E., D.L., M.P.; Mr. P. M. Evans, LL.D.; Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; The Hon. Sir Charles A. Parsons, K.C.B., LL.D., D.Sc., F.R.S.; Mr. James Swinburne, F.R.S.; Mr. Carmichael Thomas; Sir Frank Warner, K.B.E.; and Sir Alfred Yarrow, Bt., F.R.S.; with Mr. G. K. Menzies, M.A. (Secretary of the Society), and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

Lord Askwith was appointed a Treasurer in place of Dr. W. H. Maw, deceased.

Preliminary consideration was given to the question of the award of the Albert Medal for 1924.

The entries for the April section of the Examinations were reported; these are 27,280 as against 22,363 in 1923, an increase of 4,917. Fresh additions were made to the Examinations Committee.

Papers and Courses of lectures for Session 1924-25 were considered.

Other formal business was transacted.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, MARCH 21ST, 1924.

LORD LAMINGTON, G.C.M.G., G.C.I.E., in the Chair.

The paper read was:—

PROGRESS OF CO-OPERATIVE BANKING IN INDIA.

By OTTO ROTHFELD, B.A. (Oxon.), I.C.S.,
Lately member of the Bombay Legislative Council and Registrar of Co-operative Societies, Bombay.

The subject of banking, in other words the mechanism of the economic life of a nation, is so intimately connected with political, social and national conditions that I feel myself obliged to take up your time for some minutes with remarks upon the recent development of India before I approach the subject of the paper more closely.

Within the last twenty-five years that I have myself served in India, that country, if I may call it so, that continent, to be more correct, has changed and is changing so rapidly and in such essential matters, that I find those who have left India only a few years ago are but too apt to fail to recognise the vastness of the alteration.

In a sense, of course, it is as foolish to speak of India as one country as it would be to speak of Europe in such terms. Seen from outside, the difference is as great between the Punjab and Madras as it can be between Sweden and Italy. The differences are not merely those of language; they strike deep into every root of social

and economic life. At the same time it has got to be realised that in another sense India is now a united whole. In Europe we are barely conscious of that united life of European idea and custom which does undoubtedly prevail. We see the differences between countries because they are strange; we are blind to the unity because we are so habituated to it, and also perhaps because there is no equal power to set in opposition to its civilisation. There was a time when Europe, or, as it was then called, Christendom, stood for such an idea, but that was in ages when Christendom had to struggle against equal, if not superior, powers of different customs and different religions.

In India there is now such a feeling of national unity. Divergent though the inhabitant of Madras may be from the dweller in the Punjab in every detail of his daily life, yet both of them feel themselves to be in the great sense, men of one country, men of one nation, drawn up in line against opposing powers. There is, therefore, a national India in a very real living sense at this date, though twenty-five years ago such an attribute could not possibly have been predicated. That is the first great change we have to note.

The second great change is more narrowly limited to economic life. For good or for evil it has to be recognised that India has now been drawn into the general economic polity of the world. Twenty-five years ago the Indian district might still be regarded, with some slight exaggeration, as an isolated unit for economic purposes. Within that unit, the people were to a large extent self-subsistent. They produced what they required for their own consumption, and they sold the balance within their district. They depended for comparatively little upon exports from outside. When the rains failed they were subjected to famine, and they often died. Prices being so largely fixed by local conditions varied to an extent which is now almost incredible.

These conditions no longer remain. In India prices are fixed, like the prices of other countries, in the great markets of New York, Liverpool and London. Crops are grown to a preponderating extent for sale in the international market. Cultivation for subsistence is more and more going into desuetude. Since the war we know in Europe how the interests of each one of us is affected by the raids and rapacities of international finance and international commerce. The recent fall and rise of the franc in France supplies an instance in which every man and woman in the country in respect of his or her daily food finds himself successively impoverished or enriched by international capitalist intrigues and conditions entirely beyond his control or that of the mass of the people.

Similarly in India nowadays the livelihood of the humblest peasant is affected by the various moves upon the international chess-board of finance. In that respect, as in respect of internal conditions also, for good or evil, India has become capitalised.

The Presidency of India which has been most rapidly and most completely absorbed into the industrial and capitalist system is undoubtedly that of Bombay. From my own experience I can quote in particular that part of the Presidency which is known as the province of Gujerat. In that province less than twenty-five years ago, on the occasion of a severe famine, the people were still economically so backward that they would not even sell their cattle and that they refused to move a few miles in search of work. It is now an everyday occurrence for the cultivators of that province to take the train to Bombay in order to sell their cotton themselves in the best market; to no inconsiderable extent they speculate in shares; and they watch with eagerness the telegrams from the exchanges of New York and London.

The process is one which in varying degree is going on throughout India. In one part it is less acute, and in another more acute, but the metabolism is taking place everywhere and remedial measures have to be found.

The real question for the statesman and the administrator in modern India is how, given the inevitable capitalisation of the country, the people are to be prepared and protected so that they can enter with success, or at least without too much devastation, into the world of modern economic conditions. The problem is one that touches every branch of Government.

Into the other aspects of the question, however, the problem, for instance, of how to deal with the congestion of the great cities; the problem of how to secure a sufficient standard of education in so vast a continent without overwhelming taxation and too great a waste of time; the problem of undertaking legislation more or less

socialistic, it is not the purpose of this paper to enter.

The figures of illiteracy and the really dreadful figures of infant mortality, which in the city of Bombay rise as high as 600 per 1,000, give some measure of the actual situation, and the difficulties that have to be faced. It is undoubtedly true that for various reasons, for all of which the Government of India cannot be blamed, the development departments in the country have lagged far behind, and that India is in consequence handicapped to an extent far greater than was necessary.

This paper, however, is concerned only with that part of development and that side of the problem which deals with the provision of credit and in particular with its provision through and by the co-operative movement in India.

In the widest sense, of course, co-operative banking includes the provision of credit to rural societies and their members. In a sense every society that works in every village and that distributes deposits obtained from members and loans obtained from other institutions among the members for the purposes of cultivation is to that extent a bank, and certainly performs an extremely useful purpose. The object of this paper, however, is not to dwell upon the achievements of the village credit society as such. My intention is rather to present some picture of what has been done by the co-operative movement in the narrower sphere of real banking and especially with the application of co-operation to deposit banking in the modern sense.

Great as is the utility of co-operative credit in the village, managed and governed by the villagers themselves, valuable as it is morally and socially, yet I am inclined to think that in the actual conditions of the more advanced provinces at least, the extension of banking in a more technical sense in the co-operative movement is of a greater importance and of a more lasting value.

To grasp exactly what is being done by co-operative banking, it is necessary to consider first how joint stock banking stands in India. It is hardly an exaggeration to say that twenty years ago banking of any sort simply did not exist in India outside of the Presidency towns. Even to-day joint stock banks outside of those towns exist only in the most insignificant numbers and carry a weight so slight that it can hardly be termed perceptible.

The latest statistical tables relating to banks in India which I have been able to obtain were published in 1922 and are concerned with banks during the year 1920. These tables, which are published by the Government of India, divide joint-stock banks into two classes; those, namely, that have a paid-up capital and reserve of 5 lacs * and over, and those of a paid-up capital and reserve between 1 lac and 5 lacs. The banks that fall into the first class are mainly the Presidency banks, now absorbed in the Imperial Bank, and the Exchange banks.

Exchange banks do a business which hardly touches the average Indian at all. Their main business is the financing of exports and imports and dealing in exchange. The Presidency banks do valuable work for the nation as a whole by acting as treasuries for the Government, but they are so limited and restricted by rules, which are necessary for the safe performance of their primary duties, that they are of little avail to the local trader and still less to the local cultivator.

In the year 1920, including those banks, there were 58 banks in all in the whole vast continent of India. Part of these—the former class of Exchange banks and the Presidency Banks—with a few others, held nearly 11 crores in capital and reserve and 71 crores as deposits.

The second class, which alone can be of real utility to the people of India as a whole, held less than 1 crore in capital and reserve and 2½ crores as deposits.

Without at all touching upon the question of how far the joint stock banks, which fall within the second class, can be considered to be institutions that are fitted to command and deserve confidence, it will at least be obvious that their scanty number, their dispersal, and the smallness of their capital make them practically useless for any purposes of national regeneration or for any influence upon the economic life of the people as a whole.

Apart from these banks, and even including them, it may be asked what conception of banking in practice has found its way among the people. Twenty years ago it may be said that the mere conception of money in the modern sense hardly existed. Even now in most parts of India,

* NOTE.—Fifteen rupees may be taken as equivalent to the pound sterling. A *lac* is 100,000 rupees and is roughly equal to £6,600. A *crore* is ten million rupees and is roughly equal to £660,000.

and by most Indians, the idea of what is meant by money is held only in the vaguest form. Twenty years ago, to the vast majority of Indians money meant simply coins, either in gold or silver. The conception has not been greatly enlarged even to-day, but gradually the promise to pay, endorsed by the Government of India upon paper in the shape of bank notes, has come to be recognised as money of a different form. Even this promise to pay, however, is almost invariably understood to be a promise to give actual coin in exchange when it is required. The underlying conception is that of a Government hoarding vast treasuries of gold and silver coins in boxes, stored upon some remote hill-top, from which when necessary, coins may be drawn to pay the possessor of a bank note.

The fact that money is simply a promise to perform certain services, and a promise drawn upon the capacity for work of the whole nation within a period of years not beyond recognisable limits, and realised when necessary by the imposition of taxation as far as Government is concerned, has hardly yet dawned upon the mentality even of the politician.

It has sometimes been suggested that the money-lender or savkar plays a part in India such as is played by banks in all European countries. This is, however, not the case. He plays no part in regulating industry or commerce, such as is played by the modern banking system in all European countries. Really he corresponds only to the usurer of the 13th and 14th centuries in Europe, and performs much the same service. He lends actual coins at high interest and recovers in coin or in kind. He never looks to the utility or productivity of the loan. He has no wish to direct his finance to any useful purpose. When he is a man of considerable affairs, he also arranges for the transmission of credits by hundi or bill of exchange, usually at high rates of discount. But he does even this by rule of thumb and with little understanding of what actually is happening in the process. And he has always worked with the Government treasury behind him from which, in case of need, he can obtain coined money to meet his promises. It is the Government, or what amounts to the same thing, the Presidency banks acting on remunerative terms as agents for Government which arrange at great expense for the actual transmission of coin.

With your permission I should like here to quote one of my own circulars, which, to the best of my knowledge, summarises the actual position :—

"Economically the greatest evils that India suffers from are insufficient banking and want of proper organisation of capital. Most of the large sums of money absorbed each year by India are hoarded and buried in the ground. By being withdrawn from circulation, these moneys do no good to the country and are even positively harmful. What remains in circulation, is centralised to an unhealthy extent in cities like Bombay and Calcutta. The results are that industries and even ordinary trade outside of those centres languish and are starved, while what industry there is is over-stimulated and congested in two or three cities. . . . . . .

"Furthermore, joint-stock banking has had a slow and halting growth. There are still very many districts in the Presidency in which there is not a single bank in existence. Economic conditions remain mediæval and are more worthy of the times of the Pindari raids than of a civilised country with organised finance. Cheques are not used because they cannot be cashed. Even notes are not yet used sufficiently. One sees constantly a picture, which would be laughable, if it were not tragic in its portrayal of national impotence, of the merchant who carries his chests of silver or gold coin with him in a train or steamer in order to pay his customers in some wretched district which is left without a bank."

It will, therefore, I think, be readily admitted that a first condition for any adequate progress in national prosperity must be a rapid and vast extension of banking within the country. The question that remains is whether it should be left to the enterprise of joint-stock companies to institute such banking, or whether the co-operative movement as such can undertake the task and should be encouraged so to do.

Under the joint-stock system it is clear that all the profit and all the management rests with capital. It is not those who bring business to the bank who profit from its successful working and from their own custom; it is those who have put money into the bank in the form of shares.

Under the co-operative system the opposite is the case. The co-operative method is for members to associate themselves for the advantageous use of the

commodities in which they deal—in the case of a bank, the advantageous use of credit—and the co-operative method for securing that the advantage obtained by such combination should be shared by the members according to their own contributions to this advantage, is by having a rule that whatever surplus remains to the society after the payment of its necessary expenses, should be divided among the members in proportion to the business they have done with the Society. This is the co-operative rule which is freely applied in the case of trading societies such as those to which we are best accustomed in England.

In the case of credit societies or banks it has not been easy to apply the rule, but the principle is at least followed of limiting strictly the profits that go to capital, or, in other words, to shareholders. It would also seem to be reasonable that, as the business of the Society has been made by its borrowers and depositors, a proportionate rebate should be given to borrowers, and a proportionate bonus to depositors. It must, however, be confessed that the practice and legislation of various countries has not been consistent on this point.

A bill in the United States legislature makes this distribution of bonuses to depositors compulsory to all credit societies. In France, however, legislation expressly excludes depositors from sharing in the profits while making rebates to borrowers obligatory.

In India the practice has not yet been embodied in law with regard to any class of society. In the case of the Bombay Presidency, however, such a by-law has been included in the model devised for all societies and banks of this type, and is being largely followed. To whatever extent, however, such a rule may or may not be followed at the present moment, it is clear at least that the co-operative bank in all circumstances secures that capital shall have only a limited profit and that the management shall rest with the members who make use of the bank and who, therefore, will take care to insist that its working shall be to their own best interest as customers. This is an advantage at once gained by the co-operative bank over the joint stock bank.

The greater security of co-operative banks, supervised as they are by Government officers and working as they do under strict rule, is another advantage which hardly needs to be emphasised. The constant failures of joint-stock banks in India enforce the lesson. But there is more to be said than that. The existing banking institutions have not been able to develop their business to any appreciable extent even in district towns, and hardly any attempts have been made to provide banking facilities for talukas and their trade centres. Moreover, banks which already command sufficient and extensive business on present lines are disinclined to undertake a banking business with modest beginnings and modest customers in such centres. Moreover, with their centralised machinery, it is doubtful whether they could do so successfully or whether it would be possible for them to buy credit from or give it to small merchants, craftsmen or artisans.

Yet small banking facilities are a primary need of advancing India. The co-operative movement seems predestined to undertake the duty of supplying such facilities and can do so successfully. Co-operative people's banks are admirably suited for tapping local capital and stimulating the free circulation of money and of those rights to action and rights to service which are called credit, for developing local trade and fostering local industries.

The success with which this has been done in Italy is known to all the world. It is less known perhaps that in France also similar success is being achieved by co-operation. Although the law which constituted such banks in France was promulgated as late as 1917, there were already by the end of 1920, 77 such banks in the country with a working capital of about one and a half million sterling.

Such examples are an encouragement to co-operative banking in India. The progress of co-operative people's banks in the technical sense of the word has been most marked in the Bombay Presidency, and I trust you will allow me here to quote remarks made by the late Governor of Bombay, Sir George Lloyd, to whose stimulus and support co-operative banking owes so much. In addressing the Co-operative Conference in 1921 Sir George Lloyd said:—"If co-operators can succeed in establishing institutions of this class honestly working, deliberately seeking to foster the trade and craftsmanship of their towns, and introducing into the humbler homes of the people those banking practices upon which the credit and industry of Western countries is

mainly built up, they will, I can assure them, have accomplished a step for the progress and prosperity of India for which a parallel would have to be sought in the first growth of Scottish banking in the 18th century. If they accomplish such a task, I feel certain they will multiply the wealth of the country and increase the comfort of the individual citizen to an extent which perhaps none of us can imagine."

In the previous year, speaking at another Co-operative Conference, Sir George Lloyd had already said that "these urban banks have an increasingly important part to play. As they grow and extend they bring new promises of progress and prosperity to artisans, to the smaller merchants and to local industry, but their utility is by no means confined to the assistance they can directly give to these classes by way of loans and support. A bigger task lies before them. At the present moment, outside of Bombay city, it may be said almost without exaggeration that no banking facilities whatever exist, nor is there any great likelihood that the joint-stock banks will take up mofussil banking to any considerable extent in the near future. The co-operative movement has, therefore, lying before it a virgin field, and I see no reason why co-operative banks of the Luzzati type should not penetrate the whole field and take up the work of supplying this Presidency with the banking facilities which are obviously required for its prosperity."

What I should now desire to do, were it possible, would be to trace in detail the progress made by co-operative banks of this class, namely, true people's banks or urban banks, throughout India. Unfortunately the form in which the statistics and reports of the co-operative movement in India are drawn up, makes it impossible to do so with any accuracy. The statistical tables group banks of this order along with every kind of co-operative society, which deals with persons other than cultivators, and it is not possible to disentangle from the tables to what extent the figures represent banking operations conducted by real co-operative banks.

From individual reports of some of the registrars of some of the Presidencies, information is, however, available. In the case of the Bombay Presidency, for instance, for the last three or four years information has been given in full detail in a separate statement. For the other Presidencies it is known that co-operative banking of this class has been most successful in Burma and least successful in the Punjab. It also appears from an analysis of the general statement, that the banks in the Bombay Presidency have more than one-third of the working capital of such societies and banks throughout India, and that their transactions in this class amount to about one-third of the total transactions in India.

It is allowed by all critics that no portion of the co-operative movement in the Bombay Presidency has been more satisfactory than the urban co-operative banking movement. I venture, therefore, to trouble you with some detailed figures for that Presidency.

In that Presidency societies are classed as urban banks when they have a working capital of over 50,000 rupees and submit financial quarterly statements to Government. Of such banks there are now 31 in the Bombay Presidency. Of these, 15 are pure people's banks of the Luzzati type, open to all persons of every class and caste in the area, and undertaking every form of popular banking. The other 16, although otherwise working as banks, are confined either to a particular community or to persons in a particular kind of employment.

The share capital of these urban banks amounted, at the end of March, 1923, to 18½ lacs and the reserve funds to nearly 4½ lacs. Several banks had to refuse deposits as they could not utilise further funds within their area. In spite of this fact, members' deposits rose to 70 lacs, while another 16½ lacs were held for non-members; 103 lacs were lent during the course of the year; 91 lacs were repaid, and 98½ lacs in all were outstanding at the end of the year. Overdues were 5½% of the working capital.

These figures, taken as a whole, I think, are distinctly promising and shew the importance already achieved by co-operative banking of this class. It may be noted, however, that the turnover is in most cases not sufficiently rapid, while another point that is open to criticism is the insufficiency and underpayment of the staff in many cases. It seems to be difficult for Indian gentlemen to grasp that big business must imply an efficient, honest and contented office establishment. But there are institutions among those banks which, in my opinion, can face comparison with any similar institution in any part of the world. I know at least one such bank in which I am unable to

discover any point in which its working is not equal to any Luzzati bank in any Italian city of equal size and importance. These banks are more and more going to use the provincial co-operative bank as a clearing house, and the importance of the provincial bank to the movement as a whole can hardly be over-estimated.

Mention of the provincial bank brings me naturally to the second section of co-operative banking, a section perhaps more urgent at this actual moment to a larger number of people but less important probably in the near future and less interesting intrinsically. I refer by this to the system of agricultural banking which is worked by the district central co-operative banks and the provincial co-operative bank at their head.

These banks lend to societies and not to individuals. In general they lend for a period of one year and sometimes up to periods of five years. In the Bombay Presidency, under a system recently inaugurated, they may even give loans out of funds provided by Government and sanctioned in conjunction with a Government official up to a period of twenty years for permanent land improvements. The loans are always secured on the unlimited liability of all the members of the society which receives the loan. Ultimately the real security is that of the land belonging to the cultivator. The business is, therefore, one of a kind essentially steady and conservative. Their turnover is apt to be slow, their profits can never be large.

The work they do is, however, invaluable. In 1922 there were 473 banks of this class, including provincial banks, in India with a working capital just under 10 crores and a share capital of 1¼ crores. It must, however, be remembered that the figures for working capital are inflated, since moneys lent by the provincial banks to district banks appear in both balance sheets.

For India as a whole the turnover was very slow indeed, less than half of the total working capital being lent in the course of the year, and only a little more than one third being recovered. In the Bombay Presidency, where the working of the district banks and the provincial bank follows more closely than elsewhere the working of similar banks in France under the Office Nationale de Crédit Agricole, the figures shew greater banking ability and progress. At the end of March, 1923, there were 20 such banks, including the provincial bank. Including the provincial bank again, the figures of loans made were 1 crore and 48 lacs; their recoveries were 1 crore and 37 lacs; and the outstandings were just under 1 crore of rupees.

These figures shew considerable banking stability in the totals and outstandings as compared with the loans made during the year, and the recoveries received may, I think, compare favourably with most parts of India. They certainly shew that the primary purpose of agricultural banks is being kept well in view.

Excluding the provincial bank, the share capital of district banks in Bombay amounted to 13 lacs in all, and they held 55 lacs in deposit from individuals, and 9 lacs from societies. The provincial bank itself had a working capital of 85 lacs, made up of 18 lacs of non-withdrawable and long-term capital, and 67 lacs of withdrawable capital.

Before leaving the subject of co-operative banking, a few words appear to be desirable in regard to the expansion in the use of cheques and the transactions in bills of exchange conducted by and through the co-operative movement. I believe, though I am not certain, that these branches of banking within the co-operative movement are so far confined to the Bombay Presidency, and it is only in the last three years in that Presidency that they have attained any considerable extension.

I must confess that the figures given cannot be relied upon as being absolutely accurate because of some misunderstandings on the part of banks in filling up their returns. The figures may, however, be relied upon as approximately representing the total transactions. Thirteen thousand cheques appear to have been drawn on or by central banks within the last year to an aggregate value of nearly 5 crores. Urban banks drew or cashed another 5,300 cheques to an aggregate value of 1 crore. Of these there were drawn by individuals against their own accounts cheques to amounts aggregating 29 lacs. In addition some 150 agricultural village societies were reported as having had cheque transactions, the total number of cheques used by them being 4,800 to an aggregate value of 23½ lacs.

The totals in that class of bank and society amounted to 23,000 cheques to an aggregate value of 6¼ crores. Further encouragement

to the easy use of cheques has now been given by a concession of Government exempting cheques of members of societies from stamp duty up to a value of 20 rupees. In addition, transactions were reported in bills of exchange amounting to another 14,000 in all for amounts aggregating 1 crore and 80 lacs.

Compared with countries like the United States or even the British Isles, where deposit banking and the use of cheques have been familiar for generations, these figures will, of course, appearin significant. They do, however, represent substantial progress in increasing the money in circulation in the country, and furthering the wealth available at any moment, and they represent also an imponderable advance towards greater familiarity with the meaning of banking deposits and business methods. In the past, with the absence of banks and the practice of hoarding, with the difficulties encountered in the transmission of money and the ignorance of its value and meaning, one rupee in India hardly did the work even of half a rupee. With the freer use of cheques, as now being introduced among the humbler classes of the population, it may be hoped that before long each rupee will, in the course of the day, perform, as in other countries, the work of two or three rupees in adding to the circulating wealth of the country.

I trust the paper I have just read may have been adequate to give some idea of the possibilities of co-operative banking in the great dependency of India, and some idea of what already in the last few years has been attained. What has been attained goes, I think, beyond even what appears from the figures. The encouragement given by urban banks to small traders and artisans can only be measured on the spot, but experience shews that it has been of great importance and that it has restored hope where too often there had only been despondency before.

I can cite, for instance, the community of tailors in the Bombay Presidency as a particular instance. Their caste seized with particular avidity upon the idea of co-operative credit, and has made a beneficial use of it, which has improved their spirit and morale and brought back to their homes many families who had already had to seek refuge and employment in the larger towns. With increased knowledge, the hope of saving and of depositing is fast growing, and a thriftless class is being turned into a class of small capitalists.

The influence of the banks in reducing rates of interest, even among money-lenders, has been openly acknowledged, though it is difficult to chart, especially when world conditions have too often had a counteracting effect. But excessive rates of interest, demanded and obtained in India, imposed a burden almost intolerable upon improved cultivation and upon craftsmanship, and the value of co-operative banks in lowering such rates, not only for their own members, but in the surrounding countryside by their influence, is of immense value for the prosperity of the land.

Most important of all in my opinion is it that, with co-operative banking, we have at least started a system by which the powers of finance, with all that they contain of potentialities for good or evil, may be used by the people, for the people and through the people.

The work that remains to be done is still enormous, and the number of workers is still too few, but with the growing spirit of national feeling and the corresponding gain in self-respect and self-sacrifice, that number, especially among young men who are prepared to devote energy to the task and to perform it with full reliability, is noticeably increasing.

It has been said that every people gets the Jews that it deserves. It is at least as certain that no people can have a co-operative movement which it has not deserved. Unfortunately, even within the limits of the co-operative movement in India, the standard of integrity has occasionally been lower than one would have desired. But I cannot but think that the prospects for the future are bright, that integrity is increasing, and that the desire for national renaissance is providing a stimulus which will urge co-operative banking, like other forms of development in India, forward to a successful career.

DISCUSSION.

The Chairman (Lord Lamington) said that it was seventeen years since he left India, and, therefore, he could hardly offer any valuable criticism of the conditions of co-operative banking in that country to-day. When he was there the system was just starting, and from what they had heard from Mr. Rothfeld's paper the Indians were now so far changing their character as to realise

to some extent the benefits of co-operation, although formerly each man regarded his own possessions as a talent to be buried in the earth. That was, indeed, a very remarkable change. There was only one question he would like to put. He understood Mr. Rothfeld to state in one passage that the banks were supervised by Government officials. He (the Chairman) did not know to what extent such supervision existed—whether only in certain areas or universally. He would only add that he had read, from time to time, different definitions of the word "money." That evening he had heard a new definition: "Money is simply a promise to perform services." He dared say that there would be other speakers who would have a remark to make upon that statement.

The Secretary of State for India (the Right Hon. Lord Olivier, K.C.M.G., C.B.), said that he was present to pick up in the shortest and most up-to-date manner possible the latest information as to the progress of this movement in India. When he was in Jamaica he was very closely associated with one who had a good deal to do with co-operative banks, Sir James Wilson—(formerly Financial Commissioner, Punjab)—and he used to hear of the progress of the movement up to that time from him. Since then he had not heard very much about it. The author had approached the matter from the established and orthodox point of view. He himself, on the other hand, had regarded it rather from the point of view of the people whose needs gave rise to some system of co-operative banking. He would like to know in what proportion the joint-stock banks and other large banks in India were employed for financing Indian commerce, and in what proportion they were employed out of the country. The complaint which used to attach to certain banks in Jamaica was that they were more anxious to receive deposits than to employ money for the development of proper banking facilities in the island. That was a possible complaint which might, in the present disposition of the Indian people, be made against European banks in India, with what truth he did not know, and he would like some information. With regard to banking generally, in which he and many of those present became interested through their old friend, Mr. Wolff, who was present, he spoke as one who had had to do with the administration of a community like Jamaica, consisting of peasant proprietors and produce buyers. At the time of which he spoke these proprietors were always absolutely in the hands of the produce buyers or of the people in the villages who did a little money-lending business, and the result was that when their credit came to an end they were under increasing obligations to the produce buyers or the middle-men. The ordinary banks would not touch that sort of business. It was very difficult in all these communities to induce them to come together and establish a bank. He did not know what the method adopted in India had been, but it might be perhaps interesting if he told the Society very briefly what stroke of good fortune in Jamaica had enabled him to establish a system of co-operative banks there. In 1904 they had a severe hurricane in Jamaica and the coffee, cocoa, and banana plantations all over the islands were severely damaged. In order to resuscitate the cultivation the Government had to make advances to a very large number of small proprietors and peasants. They were able to save the industries and pull them through and get their money back. Two years later they had another hurricane, and the same demand was made upon the Government that they should advance money to small people all over the island. But he declared that he would not finance anybody except through the medium of co-operative banks. The banks were started and had proved a very great boon from that day to the present. The system in Jamaica was not quite the same as the one described by the author of the paper in that the buyer was assigned a share or part of the profits. If they had a loan they must take up so many shares in the bank proportionate to the loan and pay up those shares by instalments. Powers were taken to obtain first mortgage on the lands, and thus absolute security was forthcoming. By paying up their shares the cultivators had completed their obligations. The banks became progressively popular and were managed extraordinarily economically by small local committees. The committees worked voluntarily, and the secretary was generally a local man, who, for a small payment, kept a vigilant eye upon the concern. Then there had to be a central controlling and inspecting board on behalf of the Government. In course of time, no doubt, the system of making the Government the chief banker tended to be superseded, and the central banking was taken over by local banks, which brought the whole of the banking and currency system of the country into one relation. This plan might very likely enable smaller banking centres to be established on which cheques could be drawn. That was one side of the banking progress in Jamaica, that the peasant was emancipated from the produce buyer, but there was another side, about which he had not heard anything that afternoon, the side, namely, of co-operative marketing. On the one side was the producing and the obtaining of facilities for producing, on the other side co-operative marketing, and he wanted to learn something more about this latter. He gathered from the author that the cultivator and others liked to do what all simple peasant cultivators liked to do—to go down and make their own bargain. He felt that to have many peasant proprietors each making their own little bargains individually could not be nearly so advantageous as some system of co-operative bargaining. In conclusion, he remarked that all he had been able to contribute was a leaf from his experience in another country as a practical administrator who had to find for the peasant proprietor a way out of his difficulties, but his belief was that it was more difficult to get into the general mind the idea of co-operative marketing than the idea of co-operative banking.

Mr. Henry William Wolff congratulated the author upon the paper he had read, which was exceedingly interesting. Of course, Mr. Rothfeld had spoken a good deal of his own Presidency, where he and his predecessor, Mr. Ewbank, had done exceedingly good service. Bombay was not at first the very best province, but now it stood in the front rank. He was very glad to hear from the Secretary of State that something had been done in the West Indies, and he had little doubt that co-operative marketing which had been established in Jamaica would be established in India also. It was thirty years since he took upon himself to direct an appeal to the then Secretary of State for India (Lord George Hamilton) urging the passing of some Act which would legalise co-operation in that country. There were various schemes at that time for some form of insurance against damage and for co-operative effort, but Sir Frederick Nicholson's masterly report had not been published. The late Lord Wenlock told him that he had been very much interested in co-operation, having learned what was being done in other countries, in Italy particularly, and he had sent Sir Frederick Nicholson there to study the conditions. The speaker's appeal to the Secretary of State fell upon fruitful ground. He had particularly urged from the beginning, as Lord Curzon had stated in sanctioning the Act of 1904, that the co-operation necessitated in India should be based upon self-help, not upon State-help, and not upon officialism. It should be the people's own affair, governed eventually by themselves, and dependent virtually upon their own resources, with the Government aid in money at the start, cut down to a minimum. That principle was readily adopted by the authorities in India, and they stuck to it right through, finding, as unimpeachable observers had stated, that it answered admirably. The author had referred to complaints which were made that there was not more co-operation in India, and that the whole ground had not been covered. But such a complete transformation was quite impossible under the circumstances. After all, India stood foremost in respect of rapid development and the attainment of good results; in Germany, Italy, and everywhere else, excepting Russia, which had the advantage of artels, progress had been very much slower. He believed that the Indian Government had steered a right course; it had had particularly able registrars, who had shown not only zeal in this matter, but also quite wonderful command of resources. New applications had been started in various provinces which had given exceedingly good results and which really deserved emulation. The Government of Burma was now considering the question of re-organising mortgage credit. At times, of course, there had been a little impatience; summary powers and Government support had been asked for, but these had been denied, and now they saw a co-operative banking movement established with only a very small proportion of Government assistance remaining. One result of co-operation which the author had not mentioned was its most remarkable educative value. This had been seen in the way that Indians managed their self-governing councils, and in the ambition for the spread of education generally. The movement had a stimulating effect also in causing co-operators to turn to other forms of co-operation, especially in agriculture. The agricultural authorities had become the allies of co-operation, and this worked to the best advantage of the country. Lately people interested in co-operation in India had taken to travelling abroad and seeing things in other lands. He thought the time had come when India ought to be content with its own system, for that system had its own distinctive features suited to the country. He thought that the co-operative movement in India had a great future before it. Some of the people had been bitten with the idea of having co-operative stores, and had been to Manchester and Glasgow and seen the movement there. Given the well-paid artisan in India as in this country, the co-operative movement could be made as flourishing there as here, and he looked forward to the time, if the movement proceeded on the lines on which it had begun, when what a native registrar wrote about a decade ago, would be seen to be the actual fact: "Co-operation is the best gift India has yet received from its rulers."

Mr. Alan F. Fremantle, I.C.S. (United Provinces) said that as regards some complimentary remarks made that evening by the father of co-operative trade societies, the credit belonged to his brother (Mr. Selwyn Howe Fremantle). His own work, compared with his brother's in India, was very unimportant, but in his position as an Indian civil servant, as district officer, he had been Chairman of three district banks at different times. The most interesting paper had been almost above his head, because he came from such an exceedingly backward province compared with the author's, although it was one deserving of consideration, because the largest province of India, and, as many thought, the primary province. He would like to point out some of the characteristics of co-operative banking in the United Provinces so far as he had learned them. Co-operative banking was almost entirely confined to agricultural societies. The principle on which it started was rather the principle which the Secretary of State and Mr. Wolff had brought forward than the principle expounded by the author. The object was to rescue the ordinary peasant or agriculturist from the hands of the money-lender. The money-lender had to meet a great many difficulties, he had his bad debts and his legal expenses, or if he did not have legal expenses he had to keep one or two hefty retainers to go round and beat his debtors. The underlying idea, of course, was that the credit of a dozen people was better than the credit of one person. A dozen people could get a loan of 50 rupees each, as a result of co-operative credit, at a lower rate of interest than if they took out such a loan individually. The village society probably had anything between a dozen and two dozen members. They all lived in the same village, and the problem

was to get them capital. For that purpose an urban or a district bank was brought in. The bank was merely an organisation for financing the village societies; it did not have pass-books or cheque books. These village societies were scattered about the district; in a given district there might be six or seven circles, just as, in the county of Kent, for instance, a circle might be drawn around Canterbury, another around Sevenoaks, another around Tonbridge, and so on. Each of these "circles" had a secretary, who was the paid official of a headquarters bank, and received about 20 rupees a month. The expenses of the village societies were almost nil; the only cost was the expenses of two or three of the managing committee of the societies in going to headquarters three or four times a year to fetch money. The village societies, he thought, paid 12 per cent. to the headquarters financing bank for their loans, while 15 per cent. was the rate at which members of the village societies borrowed from the societies. The individual members had to buy shares in their village societies; the shares were 20 rupees, and were paid for by half-yearly instalments of one rupee. At the end of ten years, therefore, they were paid off. It might be said that the 15 per cent. was not a particularly low rate of interest, because 2 or 3 per cent. had been mentioned, but it had been found to work out quite satisfactorily and the borrowers were content. The difficulty with which they had been faced in the United Provinces was the temptation which this village finance offered to the politician. There had been a tremendous effort made in the United Provinces to get hold of the organisation of the banks. When a political clique got hold of a bank and began to appoint secretaries and to establish the whole organisation of the village societies, of course, proper co-operative banking went into the background, because a man was chosen as secretary, not for his qualifications in that office, but for his skill in spreading political views. At one place he himself had an amusing experience as chairman of a meeting at which the directors of the bank were to be appointed; a large number of gentlemen, in their eagerness to elect certain people as directors, climbed over the railings and claimed the right to vote, although they had no shares, and he had the greatest difficulty in getting the proper selection; in the end he had to give it up, and call another meeting, with a very elaborate system of tickets and examination by the police before anybody was allowed to come in. Only shareholders were then allowed to vote, and the proper persons were elected. If one were to permit the organisation of a district bank to get into the hands of the politicians it would be unfair to the original persons who financed these banks, because they never intended their money to be so used. That was a great difficulty in banking in his part of India. One would, of course, like to de-officialise everything as much as possible, but one was up against the clever lawyer-politician who did not care what became of the money, and there was a great possibility of the money being misused and misapplied, and of banking in that particular district going to utter ruin.

Mr. S. Saklatvala congratulated the author on bringing to the notice of the British public what appeared to be the most important factor in the development of the backward life of India. Mr. Rothfeld had been quite frank with regard to statistics and the fact that they were not up-to-date. Since the statistics for the Bombay Presidency were finished large banking establishments had been started in Bombay. Mr. Wolff had pointed out that the banks must not be made into State concerns. But State money in a country like India was also the people's money. While there was a sort of understanding, if not a rule, that the Government money should be held in such and such a proportion in the Presidency banks, or even in the exchange banks, the same principle might be applied with even greater justification to the co-operative banks, in which the Government might hold some of its surplus revenue. It was unreasonable to expect the people who needed the co-operative system most to build up the co-operative bank unaided. With regard to paper money, was it not a fact that paper money could not be successfully introduced into a country where the spending coin of the agricultural village was still the *pie*, or one-third of a farthing? That was the coin with which the people had to do their marketing and shopping. He believed the uplift of the economic condition was closely allied with the problem of substituting coin money for paper money.

Lord Olivier, with regard to a remark made by Mr. Fremantle as to rates of interest, said that in Jamaica money was lent to the village societies at 6 per cent., and they charged 7 per cent. to the borrowers. He did not know why the rates were so much higher in India.

Mr. J. M. Mitra, Registrar of Co-operative Societies, Bengal, said that his experience in Bengal showed that if money was lent to people at a very low rate of interest, they tended to borrow more than they could pay. It was found that if the co-operative societies borrowed money and lent it at a cheap rate it would actually deter the progress of co-operative banking. The Government of India, from the inception of the co-operative movement, limited its assistance to a very small sum, out of which it lent money to co-operative societies. One aspect of the banking movement had not been touched upon—namely, the immense possibilities of the movement in bringing the financing of trade and commerce into direct touch with agriculture. It was only through the co-operative movement that the financing of trade and commerce had been brought face to face with the financing of agriculture. The exchange and imperial banks had so far stood apart from the financing of agriculture; now they found that by lending their surplus money in times of stress, they could get the surplus funds of agriculture in times of abundance. This aspect of the progress of co-operative banking demanded some attention. It was as a part of this progress that the financing of trade and commerce had been linked with the financing of agriculture.

Mr. Rothfeld said that he was gratified to find that his paper had raised so much discussion, though the absence of any acute criticism made it difficult for him to reply. Mr. Fremantle, in his speech, unwittingly raised a point which was of the greatest importance to the development of co-operation in India, and as he (the speaker) had the honour of including in his audience the Secretary of State for India he might be allowed to emphasise this point. Mr. Fremantle had spoken of his own province as a backward one, and had said that in consequence much of the paper was above his head. The inherent difficulty was one which he had felt very strongly. What was the actual position in India? In that land there had been grouped in one federation or government countries as divergent as Serbia and Bulgaria were from England and France. They were governed by a body of men who spent six months of the year in the equivalent of Geneva and the other six months in the equivalent of Rome, which was once the capital of Europe. The officials who were occupied with conditions so diverse were recruited on a system, such as if only officials recruited in the Argentine Republic were appointed to the central European Government after two or three years spent in France or Spain, and as if these officials were looking forward to those appointments which would make it possible for them, as he had already said, to enjoy the climate of Geneva in the summer and the society of Rome in the winter. The legislation of Bombay, for example, was tested by a criterion applicable to the Punjab and Assam, which was ludicrous in the case of an industrial province like Bombay. The same thing applied to every form of banking and trade. There was failure to realise the actual conditions under which others worked and laboured. It was this which was now leading India to the breaking point, the Reform Scheme having been rendered so largely nugatory and impotent. The liberty and power intended to be conferred by the Reform Scheme had been restricted and largely taken away, and it was this which was causing grave and serious discontent and was fraught with danger for the future. To leave aside the political question, on the administrative side in connexion with a thing like co-operative banking much harm was done by grouping together every province, making them submit statements in the same form, and generally dealing with the matter in a fashion which was quite intolerable.

In answer to the questions which had been asked, he would like to say that real progress had been made in co-operative marketing in Bombay Presidency, but it was only about one-thirtieth of what it ought to be to influence the market. As for the co-operative credit societies, he had forgotten what was the total number of these in India, but in the Bombay Presidency it was 3,200, the members numbering 300,000, and a working capital amounting to 5½ crores. With regard to the co-operative banks serving as public treasuries in districts not already served by the Presidency Bank, this principle had been more or less vaguely accepted by the Government and also by the co-operative movement, but the difficulty was at present that no co-operative bank in Bombay was so far in a position to volunteer and guarantee proper performance of service. He had no doubt that one of the banks would very shortly do so, under the stimulus of encouragement which was being given. The quarterly financial statements submitted by the banks were checked, and the registrar had power of cancellation under the Act—a power which obviously could hardly be used against a district bank, but the mere existence of which served to some extent as a check. In Bombay the supervision was really exercised for them and more satisfactorily by the Provincial Bank, whose financial interests were involved. With regard to official control, he agreed that where an official was held responsible for a thing he could not allow anyone else to mismanage it. He could not, however, agree with the general implication which most officials deduce from this, namely, that he should remain responsible with and behind the non-officials. Where it was possible to let non-officials do something, the official ceased to be responsible. The moment there was a non-official body it was authorised to sink or swim. The official might have powers to control and check, which he should exercise from outside, but the idea of the collector being the president of a co-operative bank was wholly repugnant. This seemed to be distinctly inconsistent with what was intended by co-operation. With regard to his definition of money, as given in the paper, he held that by money was meant a right to exact certain services or actions from other people, or a promise to perform such services. Mr. Wolff had urged that they should not be in too much of a hurry. The speaker agreed, but the point about India was that they had no time to waste. The country had been left very far behind the needs of the modern industrial capitalised world, and if they did not hurry up as far as they could with safety it was going to be left behind hopelessly. He urged, what appeared to him to be the primary necessity of the case, to make up the tremendous leeway in education, which was nowhere felt more than in the co-operative movement. The co-operators at a recent Council election moved forward to the hustings with banners flying and bands playing. He hoped that India would move forward to education in the same spirit.

Sir Robert W. Carlyle, K.C.S.I., C.I.E., moved a vote of thanks to Mr. Rothfeld for his paper and to Lord Lamington for presiding. The co-operative movement was one in which he took the very greatest interest from its infancy and he was in close touch with it for eight years. He thought there was no movement in India which was more important and could do more to promote self-Government and co-operation in the agricultural and working classes, and the

author had shown its importance from a banking point of view in the Government of India.

The motion was carried unanimously, and the meeting terminated.

LA VIE INDUSTRIELLE EN FRANCE.

Les Usines sidérurgiques de Caen.

La Société des Hauts-Fourneaux de Caen avait été fondée en 1910 par les industriels allemands A. & F. Thyssen, avec le concours de la Société Cail. Peu après, à la suite d'une intervention du gouvernement, la participation allemande fut réduite des ¾ à ¼ seulement, lorsque la société porta son capital à 30 millions de francs. En 1914, les dépenses d'établissement s'élevaient déjà à 40 millions.

Pendant la guerre, les conventions passées avec les industriels allemands furent annulées, et la "Société Normande de Métallurgie" fut fondée par M.M. Schneider et Cie, les Forges et Aciéries de la Marine et d'Homécourt et la Société de Pont-à-Mousson. La nouvelle Société poursuivit les travaux de construction, mais le premier haut-fourneau ne fut mis en service qu'en 1917.

L'achèvement de l'usine et de ses installations accessoires fut assez lent, et la marche de l'usine fut entravée par la crise industrielle de 1921. En 1922, cependant, la reprise des affaires permit le développement de la production, et les établissements métallurgiques de Caen ont maintenant un fonctionnement normal, bien que toutes le installations prévues soient loin d'avoir été exécutées jusqu'ici.

L'usine a été édifiée sur un terrain de 400 hectares (1,000 acres), à 4 kilomètres de Caen. La Société a pu installer un port particulier de 8 mètres de profondeur, pour l'importation du charbon et l'exportation du minerai et des produits fabriqués.

Les principales installations sont les suivantes : batteries de fours à coke et usine pour le traitement des sous-produits ; hauts-fourneaux ; aciéries Thomas et Martin ; laminoirs ; fonderies et ateliers de mécanique ; centrale électrique ; services annexes (chemin de fer, port, etc. . .).

Les produits fabriqués sont les produits métallurgiques : rails, profilés, etc.. ; les sous-produits : sulfate d'ammoniaque, benzol, huiles ; enfin, les phosphates et le laitier granulé.

La disposition générale de l'usine a été étudiée très judicieusement, pour assurer la circulation méthodique des matières premières et des produits finis.

On a prévu 6 hauts-fourneaux, mais 2 seulement sont construits et en service ; ils donnent chacun 400 tonnes de fonte et 200 tonnes de laitier par 24 heures.

Chaque haut-fourneau a 27 m 30 (89′ 5″) de hauteur et un diamètre au ventre de 7 m 10 (23′ 3″). Le minerai employé provient de la région ; il contient de 42 à 54% de fer, 8 à 15% de silice, 0.6 à 0.7% de phosphore et 5% d'alumine.

Les fours à coke comportent 6 batteries de 42 fours d'une contenance unitaire de 10 tonnes. Ils sont à régénération de chaleur et à récupération des sous-produits. La production de coke est d'environ 250 tonnes par 24 heures.

Les aciéries sont logées dans un bâtiment en béton armé de 273 mètres de longueur (896 feet). L'aciérie Thomas est la plus importante, l'usine devant traiter surtout de la fonte phosphoreuse au convertisseur ; elle comprend 3 cornues et un mélangeur de 700 tonnes. L'aciérie Martin contient 5 fours de 30 à 35 tonnes.

Les laminoirs sont dans des bâtiments de 450 mètres (1,476 feet) de longueur, disposés parallèlement à l'aciérie. Jusqu'ici, deux trains seulement sont en service : un duo réversible de 0 m 90 (3 feet) à 4 cages, et un semi-continu pour la fabrication des fers marchands.

On doit prochainement compléter cette installation par des trains moyens et une tôlerie moyenne.

Aux environs de l'usine, une cité ouvrière a été construite pour le personnel, et elle offre déjà 800 logements.

Lorsque les hauts-fourneaux prévus et les nouveaux laminoirs seront tous construits, les usines de Caen constitueront sans doute le plus grand établissement métallurgique de France.

Reservoirs souterrains pour Fuel-Oil des Etablissements Arbel & Pellerin.

La Société des Etablissements Arbel (Forges de Douai) et l'Entreprise Louis Pellerin, de Paris, se sont associées pour la construction de réservoirs à liquides combustibles, tels que : pétrole, essence, alcool, mazout, gas-oil, fuel-oil, etc. Ces réservoirs sont complètement enterrés, et au besoin rendus absolument invisibles par une couche de terre recouverte de broussailles, qui les dissimule aux avions.

Ce type de réservoir est constitué par une enceinte indéformable, en béton armé ou non, construite pour résister à tous les efforts de poussée, et munie d'un revêtement intérieur formé de plaques embouties en tôle, soudées entre elles par leurs bords, et assurant leur étanchéité. La soudure de ces parois verticales est exécutée à la fois à l'intérieur et à l'extérieur de chaque panneau en tôle, suivant des lignes continues, donnant une sécurité complète pour l'étanchéité.

Les parois verticales en béton sont construites au fur et à mesure du montage des rangées de tôles, les parois de celles-ci servant de coffrage.

Les tôles, adhérant parfaitement au béton, ne peuvent se déplacer, et le réservoir ne comporte aucun risque de fuite.

Les éléments de tôles embouties sont interchangeables, ce qui simplifie la construction, et permet d'approvisionner des panneaux de rechange, pour le cas où une tôle viendrait à crever.

Le Bateau Cablier "Cyrus-Field," construit en France pour la Western Union Telegraph Co.

La dépréciation du franc par rapport à la livre sterling a eu pour conséquence de permettre à des industriels français de concurrencer des firmes britanniques dans des spécialités où elles n'avaient guère de rivales jusqu'ici. Plusieurs ateliers des environs de Paris usinent des pièces mécaniques destinées, indirectement, à l'Amirauté. Il y a quelques années, les grandes compagnies de navigation faisaient construire des navires par les chantiers britanniques; maintenant la Western Union Telegraph Co. a commandé à la Société des Chantiers et Ateliers de Saint-Nazaire (Penhoët), un navire destiné à la pose des câbles, le "Cyrus-Field."

Ce navire, qui a été lancé le 21 février, a un déplacement de 2,155 tonnes, et un tonnage de 1,070 tonneaux. Sa longueur est de 64 m 30 (211 feet), sa largeur de 10 m 36 (34 feet) et son tirant d'eau de 4 m 87 (16 feet). Ses machines ont une puissance de 1,200 chevaux et la vitesse doit être de 11,5 nœuds.

Il est à noter que la France possédait depuis de longues années plusieurs bateaux câbliers qui ont permis la pose de grands câbles transatlantiques. Le navire "François-Arago," par exemple, a posé l'un des derniers grands câbles, celui reliant directement la France au Sénégal, de Brest à Dakar.

Les Essais de Culture du Coton dans le Soudan Francais.

La diminution constante de la production cotonnière des Etats-Unis, et, par suite, de leurs exportations en coton brut, est une grave menace pour l'industrie textile européenne. Aussi, chaque pays industriel s'est mis en devoir de cultiver le coton en grand sur ses propres territoires. L'Angleterre dispose, à cet effet, des Indes et de l'Egypte, qui ont produit en 1923, respectivement 1,040,000 et 325,000 tonnes, sur un total de 4,720,000 (dont 2,600,000 pour les Etats-Unis).

On peut cultiver le cotonnier en Indo-Chine, dans les colonies françaises de la Polynésie, et en Afrique Occidentale, mais la production indochinoise sera absorbée par le marché chinois; celle des îles, du Pacifique ne sera jamais très abondante; il reste donc surtout l'Afrique occidentale, à laquelle la proximité de la métropole procure déjà un grand avantage. De plus, le cotonnier y est cultivé depuis longtemps par les indigènes pour satisfaire aux besoins locaux; sa culture paraît pouvoir s'y développer sur des espaces immenses et dans des conditions climatériques favorables.

L'Association cotonnière coloniale a, depuis un certain nombre d'années, apporté un appui très précieux aux essais tentés dans ce but, et l'industrie française a déjà, en 1923, reçu 800 tonnes de coton de l'Afrique occidentale. La région qui se prête le mieux à sa culture comprend tout le haut Sénégal et le haut Niger, jusqu'à Timbouctou. Les produits de cette région trouvent d'ailleurs une porte de sortie facile par les voies fluviales et par les deux voies ferrées qui la relient aux ports de Dakar et de Konakry.

Un vaste projet d'irrigation par les eaux du Niger a été établi, mais il serait très coûteux et de réalisation très longue. Certains ingénieurs agronomes préconisent, comme plus rapidement efficace et plus économique, la "culture sèche" du cotonnier, aidée au besoin de simples arrosages et perfectionnée par la sélection des variétés indigènes, ainsi que par leur hybridation avec les variétés américaines les plus appropriées.

NOTES ON BOOKS.

Burma, from the Earliest Times to the Present Day. By Sir J. G. Scott, K.C.I.E. London: T. Fisher Unwin, Ltd. 21s. net.

As Phayre's *History of Burma* is now scarce, and as much has happened since the annexation of Upper Burma, there is room for a complete history which would start from the old Kingly Chronicles and end with a description of Burma's essay towards reponsible Government on Western lines. No one could be more qualified than Sir George Scott to prepare such a volume; and his name is a guarantee of erudition, sympathy and comprehensive treatment. There is in his style a vein of caustic description, a criticism which the author has forestalled by admitting in his preface the possibility of a charge of flippancy. The charge is met by the statement that it is not un-Burmese.

For the Western reader real interest in Burma's story is excited when the accounts of the early European travellers in the 14th and 15th centuries are given. The descriptions of the relations with China and of the employment of Portugese mercenaries are of great interest; and later the experiences of the various British Envoys, which are given with circumstantial detail—those of Captain Symes in 1795, Captain Cox in 1796, and of Captain Canning in 1809—are illuminating as illustrative of the race pride of the Burmese.

We learn with interest that the novelist, Captain Marryatt, took part in the first Burmese War; and that King Thibaw, the subject of the Third War, survived till quite recently when he died a State prisoner in a fortress in the Bombay Presidency during the Great War. Each of the Wars showed progressive increase in knowledge, efficiency and success on the part of the British.

Of the Burmese we are told that he is incorrigibly lazy with no desire to heap up money; that he is indolent by nature and intolerant of discipline; and that one of the greatest tasks of the British Government has been to protect him against himself. The people of Burma are the most literate in the Indian Empire; and those who in recent years have promoted religious and racial antagonism are, in Sir George's opinion, not genuine Burmans.

Journal of the Royal Society of Arts.

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FRIDAY, MAY 2, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

FUND FOR PURCHASING THE SOCIETYS HOUSE.

ELEVENTH LIST.*

	£	s.	d.
Amount previously acknowledged	42,808	17	5
Brentford Gas Company ..	31	10	0
Sir Charles C. McLeod ..	25	0	0
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Captain William V. G. Fuge ..	1	0	0
Total	£42,931	15	5

The above list includes all subscriptions received up to April 26th. Further lists will be published in the *Journal* from time to time.

Fellows of the Society are reminded that the amount aimed at by the Council is £50,000, which will cover the cost of renovating and decorating the House.

*A complete list of Subscriptions received up to January 31st, was published in the *Journal* of February 15th, 1924.

NOTICES.

NEXT WEEK.

MONDAY, MAY 5th, at 8 p.m. (Extra Meeting.) T. THORNE BAKER, "Photography in Industry, Science and Medicine." SIR HERBERT JACKSON, K.B.E., F.R.S., will preside.

WEDNESDAY, MAY 7TH, at 8 p.m. (Ordinary Meeting.) J. ROBINSON, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation." ADMIRAL OF THE FLEET SIR HENRY JACKSON, G.C.B., K.C.V.O., F.R.S., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

FELLOWSHIP OF THE BRITISH EMPIRE EXHIBITION SCHOLARSHIPS.

LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, LORD LEIGH, Fellow of the Society, and LT.-COLONEL SIR HENRY MCMAHON, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I., a Vice-President of the Society, have been appointed trustees of the sums to be paid on behalf of the scholarships to be given by the Fellowship of the British Empire Exhibition.

VISIT TO THE GUILDHALL.

On behalf of the Fellows of the Society and their ladies, the Council have gratefully accepted an invitation from Mr. H. G. Downer, LL.B., a member of the Common Council, to inspect the Guildhall, including the Art Gallery of the Corporation of London, on Thursday, May 8th, at 2.30 p.m.

Sir Alfred George Temple, F.S.A., will act as escort in the Art Gallery, and Mr. Deputy Alderton, C.C., in the Council Chamber, Crypt and other places of interest in the Guildhall.

Fellows desirous of availing themselves of the invitation should inform the Secretary, Royal Society of Arts, John Street, Adelphi, W.C. 2, on or before May 6th, mentioning the number of their party. No tickets are necessary.

Those attending are requested to assemble at the main entrance to the Guildhall in King Street, Cheapside, at 2.30 p.m.

PROCEEDINGS OF THE SOCIETY.

SIXTEENTH ORDINARY MEETING.

WEDNESDAY, 26TH MARCH, 1924.

ERNEST WILLIAM MACBRIDE, ESQ., M.A., D.SC., LL.D., F.R.S., Professor of Zoology, Imperial College of Science and Technology, in the Chair.

The paper read was:—

THE FISHING INDUSTRY AND ITS BY-PRODUCTS.

By NEAL GREEN.

To compress a description of the Fishing Industry within a short paper is a most difficult task. There are so many equally important questions arising that it is impossible to discuss all, so you will perhaps excuse me if my narrative is somewhat cursory and rambling.

The British Fishing Industry is cut into two quite different parts. The Herring fishery has a long and varied history, and for centuries has been an important article of commerce; most probably taking a much larger share as an article of food for Eastern Europe than at present, so much so, that often its importance was the cause of international strife. With regard to White fishing (which includes almost all kinds of fish of white flesh, and generally trawled or caught by line), its history as a thriving industry is practically contained in the last half century. Herrings generally were salted and preserved to keep good indefinitely. White fish are not improved by this method, consequently it was only by the advent of the Railway and the possibility of a quick delivery to inland towns that trawl fishing on a truly commercial scale was possible. Quick transit and the consequent arrival of the fish in a state of freshness created a larger demand, which the introduction of the steam trawler and the manufacture of artificial ice still further improved, and this made possible the prosecution of the fishery on a very large scale. So successful was the trawl method of capture that supplies soon overtook the demand, and it was a common and truly wasteful method forty years ago to throw overboard most of the catch and bring to port only the selected kinds of better class fish, for which a demand would not be uncertain. This senseless method of carrying on the fishery was the beginning of the exhaustion of the North Sea banks. The rejectamenta thrown overboard fouled the grounds, and of course, was no advantage. Then, as the larger fish became scarcer, the smaller varieties were caught and nursery banks were interfered with, until at the outbreak of the Great War a period was reached when most of the cheaper kinds of fish consumed in this country were caught as far away as the Faroe, Iceland and North Russian grounds.

It was thought that the War years of enforced cessation of fishing in the North Sea would greatly improve conditions, but although fish were very much more plentiful for a year or so afterwards, the signs of a depleted stock of mature fish soon began again to appear, until to-day there seems to be less of these fish in the North Sea than at any time in its past history. Even the Faroe and Iceland banks are beginning to show signs of being overworked, and whereas the North Russian grounds on their discovery were packed with thin starved fish, they now produce denizens much better fed and in better condition, proving that the trawler is already thinning their ranks and thus giving more opportunities for the surviving fish to find food.

The greatest fisheries are those nearest to large populations which, by their demand for fish food, cause the neighbouring seas to be worked most extensively. In early European history the Mediterannean provided the best supply and it was this inland sea which furnished the food, the trade, and the easiest means of travel and intercourse in those days and thus promoted the earliest European civilisations. The advantages for fisheries, however, are much greater in the North Sea, as there is a constant current from the Atlantic conveying plankton, or water suitable for the growth of plankton—a word invented by Hensen to denote the enormous mass of minute species of fish and eggs, which are carried among the waters as a sort of living emulsion forming the nourishment, either directly or indirectly, for all kinds of fish. The North Sea has other advantages; it is shallow, it is fertilised by the inflow of rivers as well as ocean current; it is temperate, and it is surrounded by a coastline occupied by

enormous populations, which thereby provide a ready market for its produce. Little wonder then that it should be the most valuable fishing ground exploited. It is no mere accident that Nature providentially provides the most important fishing sea so close to our teeming population. It is the population which has made the fishery of such value. How do we know that the trawler or the line fishing boat can cause harm or diminish the ranks of marine life if worked wisely? Left alone, fish eat one another, the advent of man harrowing the sea bed with his trawl may do much more good than harm if he avoids immature fish or the beds on which they predominate. Taking the sea area of the world as a whole, it is the wolves of the sea which take the greatest toll of sea life, and to maintain the best varieties of fish man will have to reduce, if not exterminate, the useless sea monsters inimical to their well being.

There are other fishing grounds just as fertile, such as those off Newfoundland, Nova Scotia, or the western coast of Canada, but hitherto distance from the consuming population has always been a severe handicap, a disadvantage, however, that will be reduced as transport facilities improve and their neighbouring populations increase.

From the British ports the trawlers are continually going further afield, and to-day the North Sea probably supplies only about half the quantity of fish brought into this country. The banks off the Faroe Isles and Iceland are now trawled thoroughly and the North Russian coast is providing a much better quality of fish than formerly. Other banks in the North Atlantic are those contiguous to the Lofoton Isles, where the Norwegians obtain most of their cod fishery supplies; the Barentz Sea which has not yet been fully explored and may yield good supplies as the other banks fail. Also, on the Canadian side there may be good opportunities in Davis Strait and Baffin Bay, and the seas between Greenland and Iceland may prove lucrative, for to the north west of Iceland there is a submerged reef forming a shallow sea between Iceland and Greenland. There are favourable indications that we have by no means fully exploited these northern seas, for the European Stream which invades these waters most likely carries a good supply of oceanic food to maintain countless numbers of good edible fish. It is, however, in the North Sea that we find the best variety of the more highly prized fish. The turbot, sole, brill are not found in the far north, and of other kinds the North Sea provides the best qualities: this most likely is mainly because they can be landed in the freshest condition, but not altogether for this reason. There is no doubt but that as the banks vary in fertility, depth and formation, they may effect the flavour of the fish themselves. Thus plaice and soles may prefer certain banks and the astute fisherman knows where he can find them in their best condition and numbers, and when is the best time to go to these reefs or pits for his catch. In frosty weather he knows that soles are likely to creep into the pits to the south of the Dogger Bank for warmth, and for this reason often in cold weather you will find the London shops well provided with soles. Again he has to be acquainted with the migration of fish, to know that if the herring fishery is in full swing there are likely to be large shoals of codfish and haddock following the herring and consuming it and its spawn, for as the great annual herring migration takes place, it not only provides a large human population with work, it also offers itself an easy prey to foes of its own world. From a commercial point of view the herring is the most important migrating fish. Its annual pilgrimage down the East Coast of Britain has long been a phenomenon. The fishing first centres at Lerwick and Stornoway, and the drifters follow the shoals down, working successively from Wick, Peterhead, Frazerburgh, Shields, Scarborough, Grimsby, Yarmouth and Lowestoft. This annual movement of the shoals is the opportunity for a great harvest to the herring fisherman, yet little is known definitely of what really happens to the fish. They appear, and after the migration disappear, having spawned and littered the North Sea with their eggs, thereby providing a welcome feast to almost every kind of trawl fish. Of the other varieties, although there are movements, there are no definite journeys on a large scale.

It is a mistake to imagine that the North Sea fish migrate to the depths of the Atlantic. The submerged continental plateau of the North Sea is peculiarly suitable to the life of shallow-water fish, and they never leave it. A deep-sea fish, with few exceptions, such as the eel, cannot live in shallow waters, and a shallow-water fish, such as is found in the North Sea, cannot live in the depths of the Atlantic.

The softness of the flesh of the hake is owing to its habitat being the deep water of the west coast. Living in the deeps it has to bear a very much greater water pressure, and it is when this pressure is released that the flesh becomes soft. Sometimes hake are caught in the North Sea in shallower water and the firmer flesh is very noticeable.

Most of the trawl fish is now landed in the few large ports where convenient railheads serve to centralise the industry. Grimsby and Hull owe their position to the close proximity of the Dogger Bank and to the South Yorkshire collieries, which supply good steam coal within reasonable railway distance. Aberdeen mainly serves Scotland. Fleetwood has a ready market in Lancashire, whilst Swansea and Milford Haven help to supply South Wales.

Let me give you a fairly accurate description of a fishing port as seen by a visitor. This is what Monsieur Roy, a Frenchman, says of Grimsby :—

"It is a curious spectacle, the sight of the fleet of trawlers ascending the Humber from a period of two hours before flood tide, at which time the tidal gates are opened. As far as one can see the heavy, troubled waters are obscured by the smoking funnels of the boats as they hasten in, for the place which they will occupy along the pontoon is not without importance, as the sale begins at the northern extremity of the shed. Between the jetties, which are, perhaps, too close together, there is a hustling, a veritable scrimmage, of hurrying vessels, which are continually thrown against one another by colliding bows and beams; but there is never a serious collision, and it seems a miracle that there is not. The docks gradually become busy; the first arrivals tie up to the best places in the first basin; bows on to the quay, they arrange themselves in close-packed ranks. When the first dock is filled, the newcomers, in order to reach the second, have to make a sudden turn at the apex of the triangle formed by the pontoons; but they scarcely slacken speed, lest a less cautious skipper should pass his rivals. Faster and faster they arrive, urged on by the tide; taking the corner at a lively speed, bumping vigorously on the solid wooden guards of the quay, and often heeling over a considerable angle; but no harm is done; if they collide they recoil from the shock, and the great thing is to be moored to the quay in good time. Unloading commences at once; the baskets are hoisted from the hold loaded with fish; there is a continual going and coming on the gangways thrown between the bows of the vessels and the quay. The codfish, all dead, with glassy eyes, are stretched out in lots; enormous halibut spread their white bellies, some, still shaken by convulsive shudderings, opening and shutting their huge mouths. The smaller species—whiting, plaice, haddocks, etc., are arranged in wooden boxes, which are set in rows along the pavement, still impregnated with the smell of yesterday's catch, in spite of the washing it received last night. At eight o'clock the auction commences. At the northern extremity of the shed the official auctioneers bawl out the names of the fish they are offering for sale. The buyers are everywhere, stamping to and fro in their heavy boots among the slimy fish; each, as a lot is knocked down to him, replacing the seller's ticket by his own. Porters appear immediately and remove the fish as it is bought, trundling it along on barrows to the shed rented by the buyer within the market enclosure. Others have large smokehouses connected with the market. Thus the sale goes from end to end of the quays, and all the morning and afternoon an army of jostling labourers wash, scrub and pack the fish, and load it on the railway trucks. From time to time a locomotive whistles; a train is made up and pulls out of the market. Sometimes men armed with long sharp knives go by almost at a run, working at the closely packed rows of cod, plunging their knives into each fish, and snatching the livers from the slippery bodies.

The fish has now been sent in all directions: 700, 800, often 1,200 tons of fish, occupying 200, 250, or 400 wagons. Meanwhile the trawlers, who will put to sea on the following morning, have lost no time; they have filled the holds of their vessels with ice, the bunkers with coal, seen to their spare stores, and replenished their stock of victuals. The Grimsby Ice Factories, the largest of the kind in the world, are situated near the quay of the fish dock. They make about 1,000 tons of ice every day. The trawlers are supplied with coal from hulks and lighters."

Refrigeration has been successfully used in bringing meat from the ends of the earth. For fish the present methods of cold storage have the effect of breaking down the gelatinous tissues and causing loss of flavour. Frozen fish is not liked. Here is scope for scientific investigation. I have found it an advantage in preserving fish to keep the temperature of the cold store as near zero as possible, so that actual freezing does not take place. In this way it is possible to keep the fish for short periods without deleterious effect. Of course, this method is not suitable for any length of time. In America, where inland distances are great, they dry the fish into white flakes which keep wholesome indefinitely,

We have now reached a period when the trawler works on a very small margin of profit; when, owing to the price of coal, higher wages, and the increased difficulty of finding sufficient quantities of fish, there is a tendency to raise the price to the consumer, which, if it continues, may soon bring us to a day when the demand may

fall off and the industry pass its zenith. This leads us to many complex problems. We have gone from over-production, when the charges of profit levied by the fishermen, railway companies and shop-keepers were very small, to a period of under-production, when the consequent charges by those who have to live by the industry take a toll of a much greater percentage over what was taken ten years ago. We must remember that it costs twice as much to run trawlers to-day as it did then, the railway companies' charges are very much increased, and the shop-keeper, owing to a higher cost of living and increased rates and taxes, is looking for a higher percentage of profit. The costermonger, at one time a valuable agent in purveying cheap fish, seems to be disappearing, whether or not owing to the dole I cannot say. The consumer now expects his produce to be brought to his home by motor-van; the cost of which has to be added to the price, and these factors bring us to the oftentimes complaining public who eventually determine the prosperity of the industry. If people decide that fish is too dear in proportion to other foodstuffs, the demand will fall off and the fishery suffer. Fish is becoming a dearer food, but this is not caused by trusts or rings, for such a perishable commodity does not lend itself to trustification. Indeed, it might be an advantage to the industry and the public if "big business" gave the fishing industry more attention.

The only way to maintain our fishing population is to improve the methods of catching, transporting, preserving, and marketing the commodity, and to explore the possibilities of fishing banks still further afield.

The day will come soon when the depletion of mature fish in the North Sea will be a matter demanding thorough investigation by competent authorities. That depletion is taking place is abundantly proved. Thirty or forty years ago the greater part of the contents of the trawl were thrown back to rot. To-day nearly all is brought to port, and although there is still a certain amount of waste in distribution, it is not so bad as formerly. The yearly average of fish marketed in this country is about 1,200,000 tons, and of this there must be about 300,000 tons unused, for most of the heads, bones, fins, skins, etc., are thrown away by the consumer, yet of this much is now saved from the destructor.

Over one hundred thousand tons of fish and fish waste are now annually concentrated to a fine powder and fed to farm stock in this country. It is quite a simple matter to-day to convert fish into meat and this is being constantly done. This 100,000 tons is a clear gain over the waste of past years, and is a factor pointing to the possible salvation of the industry and a great source of profit to this country. Many kinds of fish are admittedly flavourless. To turn codfish into chicken is not a fanciful suggestion but a daily fact. The fish, after being converted to a dry meal containing a high proportion of albuminoids, is mixed with cereal foods and the balanced ration of albuminoids and carbo-hydrates is distinctly successful with our farmers. The intelligent stock breeder also takes advantage of the fish oils. The great nutritive value of cod-liver oil in the feeding of farm stock is shown by the National Institute for Dairy Research, who say "It is now regarded as definitely proved that the vitamin content of the milk can be raised considerably by the administration of small doses of cod liver oil to milk-yielding cows, and this without any undesirable effect on the quantity or quality of milk fat." It was only the shortage of foodstuffs occasioned by the War that overcame the English farmers' reluctance to revolutionise his feeding methods. So successful has become the introduction of fish as a cattle and poultry food, that to-day, if available, it would be easy to convert a million tons of fish into meal to the advantage of our farming industry. There is no doubt but that our egg production has been increased mainly by the use of fish-meal.

This brings a new factor into the industry, the factor of producing huge bulk supplies of fish for cattle foods and fertilisers—fish of no matter what kind, even whale, shark and dogfish—and thus taking a larger advantage of the produce of the sea. To do this the wasteful element is eliminated, climate and distance are not such greatly determining factors as formerly. It is generally admitted that the average person usually prefers fresh tasteful meat to the poorer kinds of flavourless fish, especially if the fish is not in the freshest condition. The advantages of following up fish concentration as a method of utilising the products of the sea are many. By these means it is possible to exploit fishing banks contiguous to other continents.

If the ships are completed with the necessary machinery, the concentration can be done at the fishery and the produce kept wholesome indefinitely.

Again, mankind catches the better kinds and does not seek the unpalatable species which in many cases are so voracious as to do much more damage to the fishing banks than man does himself. The porpoises of the Newfoundland banks consume hundreds of thousands of tons of good edible fish annually. A useful purpose for porpoises would soon be reflected in the multiplication of other fish. We have laws for the protection and preservation of seals, which must consume enormous amounts of valuable fish.

There is nothing so certain as that some day necessity will drive us to exploiting the open and far seas for food, and this country ought to face the possibilities before others get the advantages. The countries in the Northern Hemisphere take collectively about ninety million pounds' worth of fish annually out of the shallow seas. Wherever there is a seaboard nation with a big population, we have fisheries on a large scale. Great Britain, Canada, United States, Norway, France, Japan and China, all have large fisheries on their coasts. If this applies to the Northern Hemisphere, why do we not investigate the possibilities of the Southern Hemisphere where the water surface is so much greater? South of the Equator fishing banks are almost left alone, yet wherever there is water of 200 fathoms or less, there is a probability of a fishery. The fish may be of different kinds from those we are used to seeing on our tables, but for concentration methods it does not matter so long as they are edible. The coast fisheries of West and South Africa, South America, Australia, New Zealand, have not been pursued much because there is not a large population wanting the commodity. Yet if we can profitably fetch nitrates from Chile, frozen meat from Argentine, rabbits and apples from Australia, it should be possible to exploit the seas of the Southern World for the benefit of the excessive population of the Northern, and we may yet see huge fast-oil-driven liners ploughing through the Polar seas and laden with their produce.

Mr. James Johnstone in his book "Conditions of Life in the Sea," says :—

"From these figures it appears that the produce of a large uncultivated water area is less than that of a cultivated land area, whether we take the yield in fish or shellfish flesh, or the yield in dry substance as the basis of comparison. But a cultivated water area, such as a fresh water carp-pond, or a part of the sea near the shore treated so as to produce shellfish under the most favourable conditions, is capable of affording a rich "crop;" and if aquiculture were as intelligently studied and practised as agriculture, there can be little doubt that the sea would be more productive than the land. Thus Hensen estimated that the mass of plankton (ultimate organic substance) produced in the uncultivated Baltic was not far short of that produced upon cultivated land.

Let us attempt to compare the nature and density of life on a land surface in the temperate zone, with a sea surface of corresponding extent. If we were to explore a large tract of cultivated and forest land, in which crop-lands, meadows, woodland, streams and moorland occurred, we should find that everywhere vegetable life would be predominant, and that animal life would be comparatively sparsely distributed. Overhead in our meadow land and in the cultivated parts would be a few birds and insects, while in the soil and on the vegetation there would occur insects, worms, and here and there rodents like mice and rabbits. In the woodland animal life would be more abundant; insects would be present everywhere, and birds would be more numerous than in open country, yet birds would not be resident in every tree. Small mammals, though more numerous than in meadow land, would not be very evident. Perhaps animal life would be most abundant in the streams and lakes, but even here fishes, water insects and the aquatic mammals would not be very abundant. But everywhere vegetation would be comparatively luxuriant.

Suppose now that the waters of the North Sea were suddenly to disappear, and that the whole mass of life contained in them were suddenly to be precipitated to the sea bottom. What kind of picture would then be presented? We should see a vast, almost level plain literally carpeted with animal life. Everywhere there would be a glittering mass of fish scales, for we should see not only the fishes which live normally at the sea bottom, but also those which lived pelagically, like herring and mackerel. Hordes of invertebrates, crabs, starfishes, molluscs, etc., would be mingled with the fishes. The mud and sand would also yield their quota of living things, and these would be much more numerous than the few worms and insects contained in the land soil. Every square inch of the bottom would be heaped up with animal life, and the whole would be partially smothered by the plankton precipitated from the water. Vegetation, as it appears on the land, would be very scarce, for the sea-weeds would be confined to the coastal margin; and we should hardly recognise the plankton as of vegetable nature. The irresistible impression would be that the sea was very much richer in life than the land.

Such an impression would be an accurate one.

For production of organic substance upon the land is restricted to the surface of the soil, and to a very thin layer of the latter; while in a shallow sea, like the North Sea, production by plants is carried on throughout a stratum of water, the average thickness of which is not less than 200 feet. Though sea-weeds only exist along the shore, and at the sea bottom near the latter, yet the vegetable plankton exists practically everywhere, and at every level of the water filling up the North Sea basin. Then we find vast tracts of dry land, which are either utterly sterile, or are productive to a very slight degree. Such are desert lands; the higher rocky parts of mountainous country; the enormous tracts of land covered transitorily or permanently by snow and ice; and the relatively unproductive moorlands. And even of the productive land surface only a very small part is under cultivation. But everywhere in the sea, even under the ice and in hot and cold areas, we find abundant life. No part is sterile, and the variations in productivity are, when compared with those on the land, of little account. If we take equal average areas of land and sea, we will find that the yield of the latter is greater than that of the former. Even the comparatively poor yield in fish per acre of the North Sea is probably greater than the yield per acre of *all* the land in Great Britain and Ireland."

In this country there is a continual increase of population (for whether we like it or not there is a tendency for people to live longer in these times), and with an annual increase of 300,000 we have great difficulty in finding employment, which, of course, means the capacity to live. If our land surface is insufficient to do this, shall we not eventually be compelled to turn to the sea determined to avail ourselves to the utmost of its products?

For centuries our lands have been cultivated. We are now entering the era of the cultivation of the seas. The day must soon come when fishing grounds will have to be protected from wasteful harvesting, perhaps even the more restricted and richer submarine banks will eventually be artificially improved by the use of fertilisers and stocked with immature fish. Fifty years have not seen the life of fishery progress. Most likely they havs only ushered in the beginning. In past times competition for tracts of arid territory have brought great nations to heated rivalry, yet these important sea areas have been neglected. Who knows what the age of chemistry will discover for us? In the last few years a great industry has sprung up from the conversion of certain vegetable products into more useful foods such as butter substitutes. A newly imported food, such as the banana, pours into our country in thousands of tons and maintains a fleet of ocean carriers. Who can say what can be obtained yet from fish oils, fats, gelatines, bones, shells and the very scales of these aquatic animals? The North Pole and the South Pole have been discovered, how much more useful now to turn man's energies to the exploitation of the products of the Polar Seas; for strange as it may appear, the more temperate and cooler seas seem to be richer in marine life than the tropical waters, and the indications point to immense areas of almost uncharted seas which some day may produce material for many a thriving industry.

In the last hundred years we have seen, from small beginnings, the gradual progress into the fuller exploitation of the coal, iron and oil resources of the land. Coal, iron and brains gave us the steam engine and increased the world's horse power a million fold: the same means will give us perhaps equal progress in utilising the resources of the seas in the coming century. The journey into Polar Seas is not the lonely business it once was. The fisherman of the future will be able to listen to concerts and speeches as he pursues his vocation. He will know the state of the markets before he decides to take his cargo to land, and wireless weather reports will tell him what kind of a fishing he can expect in the near future. When his product is brought to market the manufacturer will know more about the raw material. For instance, the liver oil of the codfish already maintains a large industry, dealing with somewhere about two to three million gallons per annum, yet very little is known of its potentialities. This is a subject which our Government can help through its scientists, for it seems wasteful to sell this product to tanneries when it might have three times the value for medicinal and other purposes. I have just made some experiments in stock feeding, and find an additional growth of 20 per cent. when cod liver oil was added. Our farming industry ought to be able to absorb the whole of this product.

Of the herring, apart from its tremendous value as a food for human beings, its oil content is well worth studying. Unlike other fish the agency of man as a depredator in its ranks has not much effect. Its use as a basal food supply for other fish is so enormous, its breeding capacity so great, that it is unlikely that any very extensive

fishing will diminish its numbers. Its territorial extent is so large, going as far as Northern Iceland, that given remunerative prices the quantity taken from the Northern Seas might be five-fold: for as other fish become scarcer there are less of them feeding on it and its eggs: thus it will probably maintain its ranks.

Pressed out, its oil may have peculiar advantages over other oils for certain uses, and the residue is then more assimilative as a food for stock rearing, for once the oil is extracted there is less likelihood of the resultant meal tainting the flesh of poultry, eggs, etc. Its food value is probably higher than that of any of the common fish, and certainly it shows very bad organisation for this most valuable food to be occasionally sold at unremunerative prices. In times of glut, whether in Iceland, Norway, Scotland, or England, herrings ought never to be worth less than ten shillings a barrel for industrial purposes. To talk of hard times and dear food when we have this grand fish often wasted is a reflection on the ability of any people.

Another instance: I have received extremely valuable help from science in obtaining a perfect and extremely tenacious glue from fish, and one containing qualities absent from animal glues. These are only instances. What of sharks, porpoises, dogfish, those wolves of the sea? Full of harm alive they might at least have useful bodies with which to reward us. I know nothing of vitamines, iodines, bromines: these are subjects for our scientists: but I do know that the ocean with its teeming life has not received as much scientific and commercial investigation as it ought to have, for the material is there and the wealth enormous.

There are few chemists with any knowledge of the industry, and of books, where you will find one good one, such as Professor Johnstone's, you will find a hundred on fly fishing. Much more is known of the preference of the genus salmonidæ for certain kinds of flies than of his less handsome though very much more important brother the common cod. The new aquarium in the Zoological Gardens should be a great help in drawing attention to our common fish.

The fishing industry is going through hard times, chiefly occasioned by the high prices of coal; but it is only hard times that teach us the necessity of availing ourselves to the utmost of the by-products and other possibilities of an industry, and probably in a few years time we shall again be on the fair road of prosperity with added resources.

DISCUSSION.

The Chairman (Professor MacBride), in opening the discussion, said he supposed some of those present knew that Mr. Neal Green spoke from a wide practical experience of the Fishing Industry, being a trawlowner and factory owner on a large scale in Grimsby. He himself had rarely listened to a more instructive paper than the present one. A large number of serious questions were raised by it and they were fortunate in having several gentlemen present who had first-hand knowledge of the condition of the Fishing Industry. As it was the Chairman's duty to open the discussion, he would like to refer to the points which had struck him as the most important.

The Fishing Industry was the only one of our food industries which had remained in a primitive condition. Roughly speaking, the difference between a savage and civilised state was at bottom a difference between people who gathered food and people who produced food. In fishing they were still in the condition of gathering food, and the question was whether anything in the nature of cultivation of food production was possible. Mr. Green had hinted that considerable improvement in that direction was in sight, but he was sorry to confess that with regard to that question he was himself rather a pessimist. The sea was a thing which was exceedingly difficult to control. No doubt in certain isolated cases, where there was a tract of water surrounded by land the conditions could be controlled, and something could be done to improve the fishing production.

In particular, Mr. Green had alluded to an experiment performed by the Danes in transplanting young fish to the Dogger Bank, with the result that they grew very much more quickly. It was true that that experinent was made, but not by the Danes. It was made by our own scientific men belonging to the Marine Biological Society many years ago. The person who carried out the experiment under the direction of Dr. Allen, was Dr. Garstang, who was now Professor in Zoology at Leeds University. He was glad, however, to think the Danes had followed up those experiments which had been begun by our own countrymen. In the middle of the Dogger Bank there was an area which for some reason was not naturally reached by the fish, and in which there was a very large and abundant fauna of the material on which fish feed. It was found that if small fish were artificially transplanted to that place they would grow more quickly. But such cases were exceptions, and the best hope of getting the help of science in the fishing industry was partly, as Mr. Green had indicated, in the better utilisation of the products of the industry, and partly in enabling the fisherman to find his fish.

One of the most interesting features of the paper was the account which the Lecturer gave of the

extent to which that was now being done, and another interesting feature was the study of the life history of the fish, so that they might hope in the not distant future the Board of Fisheries would be able not only to tell the trawl-owners where they were likely to discover the fish, but to predict what kind of catch they would get. Both those matters were now rising above the horizon. It had been shown that the crop of the sea which the Lecturer accurately described as the plankton, determined the subsequent crop of mackerel in the south-west of England, and a thing which they might be able to do in two or three years' time would be to tell the fisherman in February and March what likelihood there was of getting a good catch later on in the season.

Then they had the extraordinary discovery of Dr. Hjört, the Norwegian scientist, with regard to herring, to which Mr. Green had not alluded in his paper. Dr. Hjört showed how the age of herring could be told by the number of growth rings on its scales, and found that a good production of herring only happened once in about 10 years. Yet when the statistics were taken, it was found that the production of one good year was so enormous that it supplied material for abundant fisheries for perhaps seven or eight years running. All these were directions in which science could help.

Mr. Green had alluded to the damage done by seals and porpoises, and while many people looked upon the seal as a harmless and rather beautiful creature, and likened it to a mermaid, he was entirely in agreement with what Mr. Neal Green had said about their being among the "wolves" of the sea. In this country we were imbued with what could only be described as morbid sentimentality with regard to the seal. In the Zoological Gardens before the War there were two large seals which had been presented by the Duke of Bedford, and it was calculated that at pre-war prices it cost as much to keep one of those seals in food as it cost to lodge an ordinary person in the Ritz. Except in the case of the fur-bearing kind, the seal deserved short shrift, and the same applied also to the porpoise.

The last point raised by the Lecturer was the effect of the general rise of prices on the industry. They were still suffering from that extraordinary delusion described by the Dean of St. Paul's, when he said that they had behaved at the Armistice as if they had come into a fortune, instead of having carried through one of the most exhausting and expensive wars in history, and loading themselves with a debt of £8,000,000,000. Everybody was demanding shorter hours and greatly increased wages, but from the point of view of general economy that simply could not go on. If they looked into the state of things before the war they would find capital was earning, when it was in a safe investment, something between 3 per cent. and 4 per cent. interest, which was about the lowest return which would tempt anyone to save; and yet the wages were then vastly less, and it seemed to him there was no evading the conclusion that before they could get on to a safe basis again, a readjustment in wages and hours of work would have to take place.

Mr. G. L. Alward said he had been brought up from his boyhood in the fishing trade and knew every branch of it, and would like, therefore, to congratulate the Author on his paper, with which he agreed in every particular. A good deal had been said about the utilisation of the by-products of fish, but what the British public were concerned about was fish for food, and they never realised the real value of fish for food until the recent terrible war devastated almost everything.

The suggestion of transplanting fish from one part of the sea to another was a suggestion made by a fisherman. He had helped to investigate and examine the fishing grounds of the North Sea, and it was found that in certain parts there were more young fish than could find food and nourishment as they grew bigger, and thereupon it was proposed that some portion of the flat fish, for example the plaice, should be transplanted. The result was that several millions were transferred from the shores on the east side of the North Sea to the middle of the Dogger Bank. Each one was marked, and in a short space of time they were again caught and were found to have grown enormously in two or three years—much more quickly than the same kind of fish grew in the old breeding grounds.

The Fishing Industry in this country had somewhat declined as a result of the war, but it would revive again without doubt. As to denuding the whole of the seas that was absolutely impossible. The artificial hatching of fish had been attempted by him, along with others, and the experiment in hatching out herring had been completely successful.

Mr. Arthur F. Evans could not help feeling that there was something wrong with the Fishing Industry, not indeed in the actual catching of the fish, but in the distribution and handling. There was a want of co-ordination and a want of a co-operative system. The excellent idea as to the utilisation of waste products could not be carried out in an economical and satisfactory manner without thorough co-operation.

He was astonished at the lack of co-ordination in the matter of the prices of fish. For instance, prawns were often offered in fishmongers' establishments at prices ranging from 3d. and 4d. to even as much as 6d. Probably 50 per cent. of the prawns eaten throughout the world were not caught and gathered, but farmed in the Gulf of California on farms, which were simply irrigation ditches in which prawns were fed and reared.

In a district in Hampshire there was a huge series of saltings covering some hundreds of acres, but those saltings had gone out of use. He wondered whether it would not be possible to utilise places of that description for the purpose of the cultivation of prawns or shrimps, which formed, in his opinion, a food of the greatest value weight for weight that it was possible to obtain.

The Americans did not get fresh fish, but obtained codfish from the great fishing industry in Newfoundland, and the American cooks were able to serve it up in a very palatable form. If our 1,000-ton trawlers were to go to the Northern Seas, or perhaps even to the Southern Seas, they would be able to get their fish and salt it and bring it back to this country, but we could not make use of these long-distance fishing grounds until there was some different method of dealing with fish than packing it in ice and squeezing all the life out of it, and then serving it up a slimy soggy mess.

Professor S. B. Schryver, D.Sc., said there was a very large scope for scientific work in connection with the Fishing Industry, and some of the problems had already been mentioned by previous speakers. Mr. Green, in particular, had called attention to the fact that the methods of keeping fish for a long period so that it preserved its flavour were not yet by any means satisfactory. In that alone he could see there was room for prolonged scientific research. Then again, there was the question of the methods of utilising various fish which were not largely used for human food. Altogether there seemed scope for a good many years to come for scientific work, firstly, on the question of the preservation of the fish, and secondly, on the question of the proper utilisation of waste products.

Dr. J. C. Kernot, referring to Mr. Green's experiments on stock feeding, said it was a strange thing that at present the Fishing Industry would not sell fish meal containing more than 4 per cent. or 6 per cent. of oil. A number of experiments had been carried out in connection with fish meal obtained from immature fish, and it was found that that fish meal contained about 10 per cent. of oil, which was very similar in many respects to the cod-liver oil employed by Mr. Green in his experiments.

Another point of great interest was the fact that it had been found possible to obtain from fish skins a product which was very similar to the isinglass obtained from the sturgeon bladder. As a matter of fact in some respects it was superior to isinglass. The price of isinglass in this country was something like 16s. or 17s. per lb., but the product produced in this country was considerably cheaper. This process provided a possibility for a very big industry in England. With one or two exceptions there had not been any attempt to produce from fish offal a gelatine or glue which could compete with the products imported from America, and yet the imported products sold at an enormous price, while the British product was not only cheaper but considerably better than the American.

Mr. Neal Green, in replying to the discussion, said to some extent if the American method of dealing with the marketing of fish were adopted in this country, namely, turning the fish into flakes, to be sold by the packet, it would mark a great step in the stabilisation of prices. The reason for the dearness of fish was mainly owing to the great fluctuations at the port of landing. For instance, in fine weather there was a glut of fish and the prices were low, but in a week's time there might be heavy gales and a scarcity of fish and the prices at the landings mounted up to quite four times as high as they had been a week previously. In view of those great fluctuations in supply the fishmonger naturally looked at the whole thing broadly, and protected himself as well as he could, and in doing so he naturally showed a preference for the higher price. The tendency was, therefore, to stabilise prices at a figure which would prevent his losing money on any day of shortage, and the result was that when fish was cheap he made a big profit.

Another point with regard to the marketing of fish was the question of refrigeration. There again, they came back to the question of the help to be obtained from the scientist. He did not know whether he was very grateful for the advantages he had received from the Board of Agriculture and Fisheries in collecting all those voluminous statistics they had compiled and distributed. For his own part he would not spend money in compiling statistics, but he would spend it on the scientific and industrial side. If a process of refrigeration were discovered which would prevent any deleterious effect on the fish, it would be a very big step towards the stabilisation of prices.

With regard to the question of shrimps and prawns there would be a great advantage to be obtained from the cultivation of these forms of fish. If there were restricted areas where the prawns and shrimps could be cultivated, there would be a better and fresher commodity supplied, and he did not think there would be the same amount of damage done in the North Sea which the small coasting fisherman did at the present time in the way of destroying countless millions of immature fish, which get caught in the shrimpers nets. People were inclined to complain about the damage done by trawlers to small fish, but in his opinion it was nothing like the damage which the inshore shrimper and prawner did.

A hearty vote of thanks was accorded to the author for his paper.

JAVA KAPOK.

The standard kapok, which is the floss, or fibre, produced in the pods of the kapok tree, comes from Java, and is known as prime Samarang. This material has been used for centuries by the natives for filling purposes, but not until comparatively recently has it attained any particular commercial importance. Its admirable qualities were first known to the commercial world about the year 1850, when the Dutch in Java began to export it in small quantities, first to the Netherlands,

and then to Australia and the United States. Since that time Java has been the principal, and, in fact, practically the only source of supply, despite the fact that the trees grow wild in many other tropical countries. This is due to the fact that, while in other regions there is a decided lack of a systematic method of harvesting and marketing, the Dutch merchants realized the value and potentialities of the commodity, organized their marketing system, and encouraged the natives to harvest and bring in the crops, thus inaugurating a regular export business.

The greater part of the kapok produced is used for fillers in pillows, cushions, mattresses, and similar articles of upholstery; in fact it has already acquired the rank of the premier filling fibre of commerce. Its uses for this purpose are varied and constantly increasing in number. Because of its filling capacity and durable elasticity, a mattress stuffed with the fibre will resume its original dimensions when any weight bearing upon it is removed, and the weight of a quantity of kapok required to fill a mattress is considerably less than that of any other material similarly employed.

Owing to its buoyant qualities kapok is also used for filling buoyant cushions, swimming wings, water vests, ocean waistcoats, etc.. It will not become matted as is the case with other materials. This utilization is of comparatively recent origin. The fibre now appears to be gradually replacing cork as a buoyant, and government life-saving regulations sometimes require the use of kapok as a filler in life-belts and similar life-saving devices.

The market for kapok will become further extended, it is said, when its value is better appreciated as a filler for surgical dressings. For this purpose it possesses the requisite advantages of lightness, elasticity, dryness, and suitability for dry sterilization.

The utilization of kapok for textile purposes has not met with a marked degree of success. German textile experts have attempted to spin kapok, but the experiment is reported to have been a failure unless the fibre is mixed to a large extent with long staple cotton, since the kapok fibre is short, round, brittle, and straight, while the cotton fibre is long, flat and tough, and possesses a natural twist.

From a report by the United States Vice-Consul at Soerabaya, it appears that only about 6 per cent of the Java crop is estate grown, although conservative estimates indicate that production costs could be lowered very considerably by this method. The cultivation of the fibre on a large scale for commercial purposes is carried on in Middle Java, particularly in the Residencies of Samarang and Solo, where the tree is grown in conjunction with coffee and cocoa plants. The major part of the land devoted to kapok culture is native owned. The lack of proper care in production and marketing at the present time constitutes one of the principal risks and impediments of the industry.

Kapok is one of the few crops that apparently have not been affected by the period of depression following the war. For many years the price has been comparatively steady. It is thought that there will continue to be a good market for this fibre, as the demand becomes constantly greater as a result of its increased appreciation and uses. The outlay in establishing the crop and the upkeep charges are small, and the labour and necessary machinery are inexpensive. The great advantage in kapok cultivation is that the land, in addition to bearing kapok trees, can, by reason of the small amount of shade thrown by these trees, be utilized for a wide range of additional crops.

APICULTURE IN CHILE.

According to a report by the United States Consul at Concepcion, apiculture is a minor industry throughout Chile, with the exception of the desert Provinces of the north, the southern territory of Magellan, and the central zone between Valparaiso and Talca, which lead in the production of honey and wax. In 1921 the Province of Santiago led in the number of hives, with a total of 16,992, and produced 82,400 kilos of honey and 21,100 kilos of wax. The yearly production of honey and wax and the number of hives each year since 1916 is shown in the following table:

Years*	No. of Hives.	Production of	
		Honey.	Wax.
	Number.	*Kilos.*	*Kilos.*
1916.........	115,328	868,700	110,800
1917.........	178,440	474,300	62,200
1918.........	129,466	661,700	103,600
1921.........	123,113	573,600	150,200

*Statistics not available for 1919 and 1920.

The United States continued to be the principal buyer of beeswax, but Germany took the bulk of Chile's honey. Some 70,000 pounds of beeswax were exported to the United States from Talcahuano in 1922, and 35,000 pounds during the first six months of 1923.

The gathering of honey commences in November and December, and its exportation continues from January to May. The greater part of the beeswax is exported during March, April and May. Beeswax and honey are purchased from the farmers in varying quantities by export houses and brought to warehouses in Talcahuano or Valparaiso for grading and shipping.

CORK AND ESPARTO INDUSTRIES OF CONSTANTINE.

Cork.—The cork forests of the Department of Constantine cover 403 400 hectares out of a total for the whole of Algeria of 453,820 hectares. It may be interesting to compare this area with that of other countries—France 148,680; Turkey,

116,000; Morocco, 230,000; Spain, 225,000; Portugal, 300,000, and Italy, 80,000.

From these figures, writes the British Vice-Consul at Bona in his annual report, an idea can be formed of the important place the Algerian cork trade could take in the world's market. Algeria now furnishes about one-fifth of the world's production.

The value of cork has not risen in proportion to other products owing principally to the fact that the two chief pre-war purchasers were Russia and Germany. The former country used to import a large quantity of cork slabs of all qualities for the manufacture of corks for the vodka trade. As this market is now closed and the German market not re-opened, the consequences have been that, to save the trade, it has been transformed more and more into an industry for the manufacture of corks.

Esparto Grass.—The esparto fields of the Department of Constantine are estimated at 1,250,000 hectares of which 300,000 remain unexploited. The unexploited regions exist to the south of Tebessa and between Kenchela and Batna, and are too far away from the railway for the esparto to be transported. They must wait for development till the much discussed railway for the Djebel-Onk phosphate deposits is constructed. Once this is an accomplished fact there would be a big addition to the amount of esparto shipped at Bona.

PRUNE GROWING IN FRANCE.

Three principal varieties of plums are cultivated in south-western France. The Reine-Claude, or greengage, is generally used fresh, and is shipped principally to Paris, northern France, and England. The annual production of this fruit is normally from 10,000 to 15,000 metric quintals. (1 metric quintal equals 220.46 pounds.) The St. Anthonin plum is shipped largely to England for use in making marmalade. The normal production of this variety is about 10,000 metric quintals annually. The Prune d'Ente is commercially the most important variety, which in dried form becomes the basis of the prune trade.

According to a report by the United States Consul at Bordeaux, the cultivation of the prune d'Ente is concentrated in five departments: The Gironde, Lot-et-Garonne, Tarn-et-Garonne, Dordogne, and Lot. The Lot-et-Garonne furnishes about two-thirds of the entire French production of prunes. This production is extremely variable, depending on climatic conditions and the inroads of insect pests. The normal production of the five Departments mentioned is from 100,000 to 125,000 metric quintals annually. In 1922 the crop was very small, totalling only about 15,000 metric quintals.

The prunes are dried by the harvesters in ovens similar to those used for baking bread, or simply in stoves. The fruit loses from 60 to 65 per cent of its weight through evaporation of water. The dried prunes are sorted, either by hand or by mechanical means, and are carried to the nearest market (the most important are Agen and Tonneins) where the fruit is bought by dealers, re-sorted, and packed.

While the French market, especially in the north, absorbs the greater quantity of the prune crop, about 40 per cent of the production is usually exported to England and other northern countries.

CHINESE GRASS-CLOTH WEAVING INDUSTRY.

The weaving of a snow-white fabric, entirely by hand, from the bark of hemp, is an important industry in China, writes the United States Trade Commissioner at Shanghai.

Grass cloth, known to the Chinese as "hsiapu," or summer cloth, and classified by foreigners as Chinese linen, is a special product of the provinces of Fukien, Kiangsi, Hunan, Szechwan, Kiangsu, and Kwangtung. The cloth is woven from hemp, ramie, pineapple fibre, or from a mixture of these and the bark of hemp. Whatever its constituents, it is excellent in texture and is worn to a considerable extent by both Chinese and foreigners. Compared with the finest silks and satins, the best quality of grass cloth is quite expensive.

The coarse, discoloured hemp fibres are made into cordage, mosquito nettings, bags, and mourning raiment. There is a big demand for the last-named item during mourning periods, when, according to the Chinese custom, even the rich dispense with their silks, and wear the coarsest kind of grass cloth. Sometimes these fibres are woven with cotton yarn into a kind of gauze.

Grass cloth is made in average lengths of about 50 feet, and in widths of from 12 to 14 inches. It is generally offered in 15-piece packages, but in some localities 30 to 50 pieces are bound together. The Shanghai market for this material usually opens in May, 100 pieces constituting the unit for selling. Prices vary considerably.

Chosen and Formosa are the best markets for Chinese grass cloth, although Japanese imports of this article from China have attained some importance. China is attempting to find a larger outlet through improvements in weaving, and by turning out a broader cloth of unrivalled whiteness.

NEW CHINESE MINT.

A mint is now in process of construction in Kalgan, according to a report by the United States Consul at that place. It will be known as the K'ou Pei Mint and will produce Chinese copper coins exclusively. The minting of silver coins will be undertaken after the mint has demonstrated its success in turning out copper coins. The latter are intended for circulation in the Chahar district and in the regions adjacent to the Pekin Sui-Yuan railway.

About 10 acres of land in Kalgan have been purchased, and buildings are now being erected

thereon at a cost of about £10,000. Chinese are in charge of all constructional work. The actual installation of the machinery will be done by Chinese labour under the supervision of Dr. C. H. Wang, a graduate of an American university and a metallurgical expert.

The machinery for the K'ou Pei Mint was imported from Japan six or seven years ago. It was originally intended for Shantung Province, but on account of political conditions was never used. The total value of all machinery, furnaces, presses, etc., is said to be about £75,000.

The Kalgan mint when completed will be capable of producing 500,000 copper coins in a single shift of 12 hours.

GENERAL NOTES.

Cultivation of the Oil Palm in Sumatra.—In Sumatra the cultivation of the oil palm is increasing, and several new estates were added last year to the list of producers. The output is still small, but the industry now appears to be well-established. The difficulties at first experienced in extracting the oil are being overcome, and there is every indication, writes the British Commercial Agent at Batavia, that in a few years' time the production of palm oil will be of considerable importance. Producers are finding no difficulty in disposing of their oil at good market prices, and the demand for Sumatra palm oil far exceeds the present output. The estimated output for 1922 of 1,495,000 kg. was exceeded, and the preliminary figures now available show that the actual production was 3,700,267 kg. For 1923 the estimated production is 2,535,000 kg. The production of palm kernels in 1922 was 587,716 kg.

Department of Scientific and Industrial Research.—Mr. F. S. Sinnatt, M.B.E., (Mil.), M.Sc.(Tech.), F.I.C., M.I.M.E., has been appointed Assistant Director of Fuel Research, as from 1st April. He was lecturer in Fuels in the University of Manchester, Faculty of Technology, and also Director of Research to the Lancashire and Cheshire Coal Research Association, and has been in charge of the physical and chemical survey of coal seams which the Association is carrying out for the Fuel Research Board in the Lancashire and Cheshire coal fields.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at 8 o'clock (Except where otherwise stated):—

May 5 (Monday).—T. Thorne Baker, "Photography in Industry, Science and Medicine." Sir Herbert Jackson, K.B.E., F.R.S., will preside.

May 7.—J. Robinson, M.Sc., Ph.D., F.Inst.P., Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough, "Wireless Navigation." Admiral of the Fleet Sir Henry Jackson, G.C.B., K.C.V.O., F.R.S., will preside.

May 14.—F. C. Ingrams, President of the London Fur Trade Association, "Furs and the Fur Trade."

May 21.—(Trueman Wood Lecture.) Sir William J. Pope, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, "The Outlook in Chemistry."

May 28 (at 4.30 p.m.)—Mrs. Arthur McGrath (Rosita Forbes), "The Position of the Arabs in Art and Literature." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Indian Section.

Friday afternoon, at 4.30 o'clock:—

May 2.—Jocelyn F. Thorpe, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., F.C.S., Professor of Organic Chemistry, Imperial College of Science and Technology, "Chemical Research in India." Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., will preside.

Dominions and Colonies Section.

Tuesday, May 27, at 4.30 o'clock.—C. Gilbert Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

Wednesday, June 4, at 4.30 o'clock.—The Rt. Hon. Sir Frederick Lugard, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates."

Monday, June 16, at 4.30 o'clock.—C. V. Corless, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, May 5 .. Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. M. Terry, "From East to West across Northern Australia."

Rubber Industry, Institution of (London Section), Engineers' Club, Coventry Street, W., 8 p.m. Mr. J. Fairbairn, "The Rubber Industry—a Plea for Closer Working."

Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W., 4 p.m. Mr. S. R. Whitley, "Improved Methods in the Sale and Distribution of Farm Produce."

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m.

Transport, Institute of, at the Institution of Electrical Engineers, Victoria Embankment, W.C., 5.30 p.m. Prof.

F. C. Lea, "Scientific Research and Transport."

Engineers, Society of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m. Mr. C. H. J. Clayton, "Some Factors of Sea Defence Work."

University of London, at King's College, Strand, W.C., 5.30 p.m. Prof. G. Murray, "The Historian Theopompus."

University Extension Lecture, Gresham College, Basinghall Street, E.C., 6.15 p.m. Mr. A. Compton-Rickets, "Personal Forces in Modern Literature." (Lecture I., J. M. Barrie.)

TUESDAY, MAY 6 .. Zoological Society, Regent's Park, N.W., 5.30 p.m. 1, Mr. R. Broom, "On Some Points in the Structure of the Pareiasaurian Skull." 2, Mr. D. M. S. Watson, "The Elasmosaurid Shoulder-Girdle and Fore-Limb."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. J. Barcroft, "The Effect of Altitude on Man." (Lecture II.)

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. W. G. Constable, "The History of Decorative Painting in England." (Lecture II.) 5.30 p.m. Prof. J. G. Robertson, "Byron and Goethe." (Lecture II.)

Alpine Club, 23, Savile Row, W., 8.30 p.m. Mr. J. A. Parker, "The Pyrenees."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Dr. C. E. K. Mees, "Tone Reproduction in Photography" (Hunter and Driffield Memorial Lecture)

WEDNESDAY, MAY 7 . Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5 p.m.

Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. (Wireless Section). Mr. L. C. Pocock, "Faithful Reproduction of Radio Telephony."

University of London, King's College, Strand, W.C., 5.30 p.m. Sir Halford Mackinder, "The Communications of the Empire."

Public Analysts, Society of, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m., 1, Messrs. J. H. Lane and L. Eynon, "Determination of Sugar in Urine by means of Fehling's Solution with Methylene Blue as Internal Indicator." 2. Mr. J. Considene, "Simple Forms of Hydrogen Electrode." 3. Messrs. K. A. Williams and E. R. Bolton, "Note on the Recognition of Hydrogenated Oils." 4. Dr. A. T. Etheridge, "Estimation of Copper and Tin and Copper-Tin Alloys." 5. Mr. D. W. Steuart, "Notes on the Analysis of Milk Powders and Condensed Milks."

THURSDAY, MAY 8 Electrical Engineers, Institution of, Victoria Embankment, W.C., 6 p.m. Annual General Meeting.

Historical Society, 22, Russell Square, W.C., 5 p.m. Miss E. C. Lodge, "An Episode of the English Rule in Gascony during the 13th Century."

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Annual Meeting. Address by the Chairman, the Hon. Sir John Cockburn.

Mechanical Engineers, Institution of (Graduates' Section, N.W. Branch), at the Engineers' Club, Albert Square, Manchester, 7.15 p.m. Mr. C. Eatough, "The Manufacture of Worm Gearing."

Royal Institution, Albemarle Street, W.1. 5.15 p.m. Mr. F. Balfour Browne, "Social Life among Insects." (Lecture II.)

Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W., 10.30 a.m. Annual Meeting. 1. Presidential Address by Sir William Ellis. 3. Mr. J. P. Bedson, "Continuous Rolling Mills; their growth and development." 2. Messrs. J. H. Andrew and H. Hyman, "High temperature growth of special Cast Irons." 2.30 p.m. 4. Messrs. F. C. Thompson and W. E. W. Millington, "The Plastic deformation of α and γ Iron." 5. Mr. O'Neill, "The effect of cold-work upon the density of α Iron." 6. Messrs. C. A. Edwards and L. P. Pfeil, "The production of large Crystals by annealing Strained Iron." 7. Messrs. A. Westgren and G. Phragmen, "X-Ray Studies on the Crystal Structure of Steel." Part II.

University of London. University College, Gower Street, W.C., 5.30 p.m. Senator Prof. A. Crippico, "Lirici italiani contemporanei." (In Italian). 5.15 p.m. Prof. J. E. G. de Montmorency, "The History of Leagues of Nations." (Lecture I.)

At King's College, Strand, W.C., 5.30 p.m. Mr. A. del Re, "English Influences in Italian Literituro during the 18th Century.' (Lecture I.)

5.30 p.m. Senor Don José Castellejo, "Education in Spain—its Organisation Problems, and Attempts at Reform." (Lecture III.)

Auctioneers' and Estate Agents' Institute, 34, Russell Square, W.C., 3 p.m. Annual General Meeting.

FRIDAY, MAY 9 . Chadwick Trust, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.15 p.m. Prof. MacBride, "Some Causes of a C3 Population."

Royal Institution, Albemarle Street, W., 9 p.m. Prof. V. F. K. Bjerknes, "The Forces which lift Aeroplanes."

Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W., 10.30 a.m. Annual Meeting continued. 1. Mr. W. Dryssen, "Recovery of Waste Heat in Open Hearth Practice." 2. Mr. J. Seigle, "Theoretical considerations respecting certain features in the working and efficiency of Reversing Regenerators." 3. Mr. K. Honda, "On the Forging Temperature of Steels." 4. Messrs. K. Honda and K. Takahasi, "On the Indentation Hardness of Metals." 5. Messrs. A. L. Norbury and T. Samuel, "Experiments on the Brinell-tensile relationship." 2.30 p.m. 6. Messrs. G. S. Bell and C. H. Adamson, "Transverse test bars and Engineering Formulæ.' 7. Messrs. E. W. Colbeck and D. Hanson, "The Hardening of Silico-Manganese Steels." 8. Mr. D. J. MacNaughtan, "Hardness of Electro-deposited Iron, Nickel, Cobalt and Copper." 9. Messrs. L. Atchison and W. L. Johnson, "Notes on the testing of Metal Strip." 10. Mr. W. N. Hindley, "Some effects of the penetration of Arsenic and Sulphur into Steel."

Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Malacological Society, at the Linnean Society, Burlington House, Piccadilly, W.

Aeronautical Engineers, Institution of, Engineers' Club, Coventry Street, W., 6.30 p.m. Captain W. H. Sayers, "Some Possible Future Developments in Aeronautics."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Mr. R. W. Allen, "Irrigation Pumping Machinery" (Gezira Scheme).

Sanitary Institute, Town Hall, Tunbridge Wells, 5 p.m. 1. Mr. W. H. Maxwell, "Tunbridge Wells Undertakings"; "Water Bearing Strata in and around Tunbridge Wells"; "Rainfall and Drought in 1921." 2. Dr. F. C. Linton, "Child Welfare Work, retrospective and prospective."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. B. Park, "Picture Making in the Pyrenees and the little known Republic of Andorra: by Mule and Motor."

SATURDAY, MAY 10 .. Royal Institution, Albemarle Street, W., 3 p.m. Dr. F. A. E. Crew, "Heredity and Sex."

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FRIDAY, MAY 9, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 14TH, at 8 p.m. (Ordinary Meeting.) F. C. INGRAMS, President of the London Fur Trade Association, "Furs and the Fur Trade." ERNEST POLAND, Vice-President of the London Fur Trade Association, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

NINETEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 30TH, 1924; MR. HARRY GOSLING, C.H., M.P., Minister of Transport, in the Chair.

The following candidates were proposed for election as Fellows of the Society:-

Archibald, John Smith, Montreal, Canada.
d'Erlanger, Baron Emile Beaumont, London.
Drake, William Allen, Dayton, Ohio, U.S.A.
Flavelle, Sir Joseph Wesley, Bt., Toronto, Canada.
Fleming, Alfred, Southsea, Hants.
Garrigues, H., Copenhagen, Denmark.
Hodges, Gordon, London.
Izod, Edwin Gilbert, Johannesburg, Transvaal, South Africa.
Lynn, Scott, Mem.A.I.E.E., Toronto, Canada.
Nicholson, Reginald, M.B.E., Midhurst, Sussex.
Rai, H., Indore, Central India.
Whitby, Thomas Broom, Nottingham.
Williams, Frederic N., Shreveport, Louisiana, U.S.A.

The following candidates were duly elected Fellows of the Society:-

Aisinman, Dr. Semion, Paris, France.
Crichton, Alexander, New Brunswick, Canada.
Fazul, Mehr Ali, L.C.E., A.M.I.E., Hyderabad, Deccan, India.
Fern, William G., London and South Africa.
Mepham, George S., St. Louis, Missouri, U.S.A.
Miolée, Willem Frederik, Bulawayo, South Africa.
Moll, Thomas, Bedford.
Parsons, Frederick, Massachusetts, U.S.A.
Robertson, James Alexander, O.B.E., J.P., Cleveleys, via Blackpool.
Rusk, Professor Rogers D., M.A., B.S., Naperville, Illinois, U.S.A.

A paper on "The Victoria Dock District and its Roads" was read by BRIGADIER-GENERAL SIR HENRY MAYBURY, K.C.M.G., C.B., Director-General of Roads, Ministry of Transport.

The paper and discussion will be published in a subsequent number of the *Journal.*

INDIAN SECTION.

FRIDAY, MAY 2nd, 1924; SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in the Chair.

A paper on "Chemical Research in India" was read by DR. JOCELYN F. THORPE, C.B.E., F.R.S., Professor of Organic Chemistry, Imperial College of Science and Technology.

The paper and discussion will be published in a subsequent number of the *Journal.*

EXTRA MEETING.

MONDAY, MAY 5th, 1924; SIR HERBERT JACKSON, K.B.E., F.R.S., in the Chair.

A paper on "Photography in Industry, Science and Medicine" was read by MR. T. THORNE BAKER.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, FEBRUARY 15TH, 1924.

LORD MESTON, K.C.S.I., LL.D., in the Chair.

THE CHAIRMAN, in introducing the reader of the paper, said they would probably suspect him of some exaggeration when he said that it was now 50 years since Sir Richard Dane entered the Punjab as Assistant Commissioner. He commenced in 1874 that long and distinguished career, which incidentally had the effect of endearing him, almost beyond any man of his time, to the people of the Punjab. In 1898 he became Com-

missioner of the North India Salt Revenue, an office which, in those days, was regarded as one of the very few sinecures in India. In Sir Richard's hands, however, it soon ceased to be a sinecure. He took up the work with his accustomed zeal and changed it into a live appointment, indeed so live that when in 1907 the office of Inspector-General of Excise and Salt for India was created there was obviously only one man to fill it. Sir Richard Dane had acquired a command of the subject which was available in the hands of no other person in India at that time. He set to work on that post again with the same zeal and assiduity that had endeared him to his colleagues in other capacities. The speaker did not think the Government of India realised at the time, although it did realise later, the economies which Sir Richard Dane was able to enforce in his control of the combined offices, the enormous stimulus he gave to the revenue, and the influence that he had on the extremely difficult subjects connected with Excise which were then, as now, the focus of controversy. In 1909, however, the Procrustean rule of age came into operation, and Sir Richard Dane had to go. He did not think Sir Richard Dane's labours in India were altogether uninterrupted by lighter pursuits, and he dared say on an afternoon like the present, Sir Richard Dane often thought longingly of the trout streams and the tiger jungles that insisted on forcing themselves in his way during his arduous searches for new salt sources. But he retired, not, however, to sit at home and to flog the rivers of his own beloved country, which he had done with considerable success, but to find a new sphere in which his remarkable genius could manifest itself. Within a few years of his retirement, China found itself looking over the world for someone to carry on the task and maintain the extraordinarily high standard set by Sir Robert Hart. Obviously, in Europe, there was only one man who could do this, and so Sir Richard Dane had to put on his harness again and go out East once more. His career in China was too recent and too well-known to require any eulogy that afternoon, but here he was, having finished his experiences in China and in India, and he had come to talk to the Society on a subject of which he feared few of those present knew very much. He would at once ask him to read his paper.

The paper read was :—

THE MANUFACTURE OF SALT IN INDIA.*

By Sir Richard M. Dane, K.C.I.E.

Commissioner, North India Salt Revenue, 1898-1907, and Inspector-General of Excise and Salt for India, 1907-1909.

In a pamphlet, published in 1884 for the International Health Exhibition and for the Royal Society of Arts, Mr. Manley made the statement that "the salt produced in India, whether from washing salt-soil, or from the mines in the Salt Range in the Punjab, or from the evaporation of sea-water on the coast, was, and is still, of an inferior character, more or less dirty in colour, and containing from 10 to 12 per cent. of impurities." The statement, so far as Punjab rock-salt is concerned, is incorrect ; as this salt, though it is usually pink in colour, is as pure as English salt. Much of the salt made in Rajputana also is of very good quality ; and in some places in the Province of Sind perfectly pure naturally-formed salt can be collected. It is, however, the case that, except in the north-west of the country, India is not well-provided with good salt ; and the salt made from sea-water by solar heat on the coasts of Bombay and Madras has not, up to the present time, been as good as salt made from sea-water by the same process in other countries.

In the South of India salt appears to have been made from sea-water by solar heat from time immemorial. The populous Provinces of Bengal, Bihar and Orissa were also, in former times, supplied with salt made locally on the sea-coast. The climate of Bengal is, however, too moist, and the density of the sea-water in the Bay is too low to permit of the manufacture of salt by solar heat. Low-lying areas were flooded with sea-water ; and, when the water dried up, a saline efflorescence was formed. This efflorescence, with the saline mud and sand below, was collected : fresh sea-water was passed through it, and the strong brine so obtained was boiled down until salt was precipitated.

In the interior of the country the Rajputana sources were worked, and Punjab rock-salt, lying on or near the surface, was excavated ; but transportation was so costly and difficult that salt, made locally from saline earth and from subterranean brine, was used whenever it could be obtained, however impure it might be. Under Native rule a revenue from salt appears to have been derived, mainly from transit duties, which were collected at barriers established for the purpose on all important trade routes. The taxation was progressive : at each barrier that the transporter arrived at duty had to be paid again ; and this system added materially to the difficulty and cost of transportation, and helped to stimulate local production.

* Burma is not included.

The manufacture of salt in India, especially in the Upper Provinces, has been so profoundly modified by the policy of the East India Company and of the Government of India under the Crown, that any account of manufacture must largely be a description of that policy. In the early days of British rule, the possibilities of salt as a source of revenue attracted the attention of the Company's servants in Bengal: and, in 1780, Warren Hastings established a monopoly of the production and sale of salt, on behalf of the Government, in Bengal, Bihar and Orissa. Government agencies were established in Orissa and in the coast districts of Bengal: the agent made advances to the salt-makers and purchased the manufactured salt from them at fixed prices; and the salt so purchased was sold to the public on behalf of the Government. The system ensured the production of a supply of salt, which was considered by the Government to be adequate for the needs of the population, and appears to have been well-suited to the circumstances of the time: and for 50 years after the establishment of the monopoly no serious question appears to have been raised as to its propriety. After the withdrawal of the Company's monopoly of Indian trade, foreign salt appears to have been carried to Calcutta for sale as early as 1818-19: but the quantity for many years was small. In 1835-36 the quantity of salt made locally under the monopoly was 162,000 tons, and the quantity of foreign salt imported was 10,000 tons only. The foreign salt at this time was brought by Arabs in their dhows from Muscat and the Red Sea: the Government did not encourage the importation, and English salt merchants took no part in the trade. In 1845-47, however, a determined attack was made on the monopoly by the English salt merchants and by the press. The salt made was bad, as no improvement appears to have been found possible in the native methods of manufacture. The taxation was high, and the salt was very dear; and it was urged that the monopoly was a form of trading, and was, therefore, a violation of the conditions of the Company's Charter. Under pressure of this attack the stringency of the monopoly was relaxed; and the manufacture of salt by private individuals, under a system of Excise, was permitted both in Bengal and Orissa. The duty also was reduced; and greater facilities appear to have been given to importers of foreign salt, as after this the imports rose rapidly. In 1851-52 they amounted to 110,000 tons.

In Bengal attempts were made by private individuals from time to time to make salt for sale, on payment of the Government duty, but they were unsuccessful. In Orissa manufacture was found to be profitable, and was carried on for many years.

The monopoly survived until the Government of India was assumed by the Crown; but, in 1862, it was decided to abolish it and to leave the supply of salt to the three provinces entirely to private enterprise. The agencies were gradually abolished. In the three years ending with 1873-74, when the monopoly stocks were exhausted, the average quantity of foreign salt annually imported was 276,000 tons; and 78 per cent. of this was English salt.

The territory which the Company acquired in 1801 and 1803 to the north-west of Behar (now forming part of the United Provinces) was supplied with salt from the Nuh and Sultanpur salt works in what are now the Gurgaon and Rohtak districts of the Punjab, from works in the Native State of Bhartpur, and from local works for the manufacture of earth-salt. Some salt also was imported from the Sambhar Lake. For more than 30 years salt in this territory was taxed by the company as an item on an Inland Customs Tariff, very much in the way in which it had been taxed under Native rule. The collection under this system of anything more than a nominal duty upon locally-made earth-salt was found to be impracticable. The revenue derived from a number of articles on the Customs Tariff was insignificant: while the collections on imported salt from Rajputana formed the most important item in the total Customs revenue. In 1834, therefore, it was decided to abolish the Inland Customs Houses; to prohibit the manufacture of alimentary salt east of the Jumna; and to collect import and export duties on salt and on some other articles at a Customs Line established along the southern and western border of British territory. In 1838 it was found necessary to relax for a time the prohibition of the manufacture of earth-salt. But in 1843 full effect was given to the new policy. All goods, except salt, sugar and cotton, were exempted from taxation: the manufacture of earth-salt in the territory within

the Customs line was made illegal, and smuggling was made a criminal offence.

After the annexation of the Punjab, the Line was carried along the south of that Province to the Indus, and thence along the left bank of that river to Torbela at the eastern limit of the Peshawar district. In 1855-56 the cotton duties were abolished, but the Line was extended to include the greater part of the Central Provinces: and, in 1867, it was further extended round Berar.

The Line was at this time a most notable landmark. It ran from Torbela to a point on the Mahanadi, a distance of 2,472 miles; and was guarded by an army of 12,911 officers and men. Consignments of salt and sugar were liable to examination when they entered the jurisdiction of the Line, which was a zone 10 to 15 miles in width, and were examined at the posts open for trade and traffic, all of which were under European supervision. Wherever it was possible, a hedge was cultivated so as to form a natural barrier; and in places the hedge thus formed was impenetrable.

Within the area thus ringed in, (which, after the annexation of the Province, included Oudh), the manufacture of earth-salt was suppressed. In the Agra and Oudh Provinces suppression was effected with much difficulty. The salt-makers abandoned their hereditary avocation with reluctance; and the difficulty of suppression was increased by the existence of an important saltpetre industry. A factory for the manufacture of crude saltpetre serves equally for the manufacture of earth-salt. In time, however, by the employment of large preventive establishments, suppression was effected. In Oudh, where the locally-made earth-salt had a high reputation, and imported salt was dear owing to the high cost of transportation, the policy of suppressing the local industry was sharply criticised by the Chief Commissioner in 1867. The manufacture of earth-salt was accordingly again permitted under a system of Excise in the Unao district of Oudh and the Jaunpur district of the Agra Province: and an Act was passed to legalise the experiment. The salt, when made, was, however, found to be so inferior to the Bhartpur and Sultanpur salts, which were then in general use, that the Jaunpur salt had to be destroyed, and the Unao salt was disposed of with great difficulty. Manufacture was, therefore, discontinued after one season.

The establishment of the Customs Line produced a large increase of revenue: and, in 1859, the taxation of salt in the Upper Provinces was raised to the rate in force in Bengal, Behar and Orissa. But the Line, though it involved less harassment of the people than the system of Inland Customs taxation which preceded it, was a great obstruction to trade and traffic; and supervision, however close, could not entirely prevent the occurrence of cases of oppression. Within the Line also salt was undesirably dear. It was felt, moreover, to be inequitable that salt should be taxed so much more highly in Upper India than it was in Madras and Bombay. In 1861 the salt duty in the Upper Provinces was 3 Rs., and in Bengal it was 3 Rs. 4as. per maund of 82 $\frac{2}{7}$ lbs. In Madras and Bombay it was 1 R. 4as. per maund. These considerations led to the abolition of the Line and the equalisation of the salt duties throughout India. The Line was actually abolished in 1879; but the policy was foreshadowed ten years earlier, when, in the Review of the Annual Report of the Inland Customs Department of 1868-69, the Governor-General observed that "the object to be aimed at was the equalisation of the price of salt throughout India." Control of the Inland Customs Department, which up to this time had been exercised by the Government of the United Provinces, was transferred to the Government of India: the management of the mines in the Salt Range was transferred from the Punjab Government to the Department; and the Sambhar Salt Lake was leased by the Government from the Native States of Jodhpur and Jaipur, to which it belonged. For some years after the lease of the lake, the Government officers there posted merely supervised the manufacture and sale of salt: and duty was collected on the salt when it crossed the Customs Line. As transportation was difficult and expensive, and the transporters were harassed by the transit duties which were collected en route, the trade in Sambhar salt did not develop rapidly. In the five years ending with 1868-69, 43,000 tons of Bhartpur salt, 31,000 tons of Gurgaon and Rohtak salt, 20,700 tons of Sambhar salt, and 11,400 tons of Didwana salt were transported annually across the Line into the United Provinces and the Punjab. In the nine years ending with 1877-78 the annual imports of Sambhar salt rose to 29,800 tons,

and the imports of Bhartpur salt fell to 37,000 tons. The imports of other salts did not materially vary. When Sambhar was linked by railway with Delhi and Agra in 1875, and arrangements were made to supply salt direct from the lake to traders in the United Provinces, the superiority of the lake salt began to tell. The construction of railways and the imposition of an uniform salt duty irrespective of quality, a measure which is more expedient than just, were important contributory causes of the destruction of many of the less valuable salt sources in Upper India.

By 1875 the abolition of the Customs Line was decided on. In the debate in Council on the Inland Customs Act of that year, Lord Northbrook said that the Line was recognised to be "a great evil," and that he anticipated with confidence the completion of arrangements which would permit of its abolition. The salt sources of Didwana, Pachbadra, Falodi and Luni in Jodhpur and Kachor Rewasa in Jaipur were accordingly leased from the Darbars; and agreements were negotiated with other Native States in Rajputana and Central India, which provided for the closure on payment of compensation of unimportant salt sources, and for the restriction of the outturn of others, which were left open under the management of the Darbars: for the suppression of the manufacture of earth-salt, and for the abolition of transit duties and of all restrictions upon the trade in salt, on which duty had been paid to the Government of India.

The Bhartpur salt works were closed by the Maharaja in 1876-77. He was unwilling to lease the works to the British Government, and said, with truth, that Bhartpur salt could not compete with Sambhar under the conditions which had been created by the construction of the railway, and by the abolition of the transit duties. Compensation was paid by the Government of India to the salt-makers. The Maharaja receives an assignment of Rs. 150,000 a year from the salt revenue; and salt, upon which duty has been paid to the Government of India, is consumed in the State. If the works had been leased, it is practically certain that they could not have been profitably worked; but the closure of works, which were at the time, and probably had been from time immemorial, the principal source of supply for the Agra Province, was a noteworthy incident.

The duty on salt in Madras and Bombay, which had been raised to 1 R. 13as. in 1869-70, was raised further to 2 Rs. 8as. in December, 1877; and, in July, 1878, the Government directed that this rate of duty should be adopted throughout India. The sugar duties were remitted from 1st April, 1878. The Customs Line was removed soon afterwards, but a line of posts along the Indus was maintained until 1896 to exclude Kohat rock salt from the cis-Indus districts.

Of the five minor sources leased from Jodhpur and Jaipur only Didwana and Pachbadra are worked. The salt-makers at Kachor Rewasa were unwilling to make salt for sale to the Government of India. Falodi and the Luni were worked for a time; but without railway communication it was found to be impossible to work them profitably. The Luni, therefore, was closed in 1887-88, and Falodi in 1897-98.

The works at Nuh in the Gurgaon district failed almost immediately after the adoption of this policy. Over 18,000 tons of salt were taken over by the Northern India Salt Department (which took the place of the Inland Customs Department), but nearly all of it had to be destroyed as unsaleable. The Sultanpur works, though they are on a branch of the Rajputana Malwa railway, were practically destroyed by the competition of Sambhar salt before the end of the 19th century.

As a set-off against this destruction of salt sources, two important groups of new salt works were opened in Western India. In 1875, after the construction of the Bombay Baroda Railway, Sir C. Pritchard, who was then in charge of the salt administration in Bombay, concentrated the manufacture of salt, which was scattered along the shores of the Lesser Runn of Cutch, at Government works at Kharaghoda. The salt made is good, and the works now play a very important part in the supply of Upper India.

In Sind, also, when the Salt Department was reorganised and the suppression of the manufacture of earth-salt was undertaken in 1878, some other salt had to be provided to take the place of the earth-salt, which was up to this time the salt commonly used in the greater part of the Province. New works were, therefore, established on the Moach Plain near Karachi by Mr. Maury, of the Bombay Salt Department; and the greater part of the salt consumed in Sind is obtained from these works.

By these measures the arrangements for the manufacture and supply of salt throughout India were placed substantially upon their present footing. The policy of the Government, as laid down by the Secretary of State in 1881, is to permit the freest possible competition between the different kinds of salt; and, so long as an adequate supply of salt is assured, this policy unquestionably conduces to the interest both of the people and of the Government. In the competition quality and cost are usually the determining factors; but sometimes success is determined by preference. People who have been accustomed to consume sea-salt are very unwilling to use any other; and many other instances of preference, some of which appear to be unreasonable, can be given.

The south of India, Berar and the greater part of the Central Provinces are supplied with Bombay and Madras sea-salt. Bengal and Assam are supplied entirely with foreign salt, and Behar also is supplied mainly with this salt. Orissa, where the local salt-boiling industry was suppressed in 1889, is supplied largely with Madras salt, but partly also with foreign salt. Kohat salt, excavated from quarries which are in private ownership, is consumed in the trans-Indus territory; but the Punjab, the United Provinces, Rajputana, Central India, and part of the Central Provinces are supplied from the Punjab mines, the three Rajputana sources and the works on the Lesser Runn of Cutch; and all these sources are under direct Government management. About 8,000 tons of salt are produced annually at the quarries in the Native State of Mandi in the Himalayas, the Sultanpur works and the few works that were not closed in Native States in Rajputana and Central India; but this contribution is comparatively insignificant. Sind also is supplied from sources which are under direct Government management.

The trade in salt is encouraged. Foreign salt can be bonded without payment of duty in public warehouses: in Bombay and Madras credit for payment of the duty is allowed to merchants executing a bond and depositing adequate security; and in Northern India and at Kharaghoda a so-called Through Traffic system has been most efficacious in reducing the price of salt to the consumer. Under this system traders are able to obtain salt direct from the sources without the intervention of middlemen, by depositing the price and duty and a small fee for bagging and clearance in any Government treasury or authorised Post Office, and by sending a receipted indent with a supply of bags to the officer in charge of the source. Before the war over 2,500 dealers purchased Punjab rock-salt, and about 2,000 purchased Sambhar and Pachbadra salt, direct from the sources; and in the nine years that I was Salt Commissioner only one of the thousands of transactions that took place formed the subject of legal proceedings.

In the three years ending with 1921-22, the total annual outturn of salt in India was 1,454,000 tons; and Bombay and Madras sea-salt represented 58 per cent. of this total. The larger quantity of salt is produced in Madras. The present normal annual output of salt in Bombay is about 370,000 tons; in Madras it is about 450,000. But in Madras, with its large population and high rate of consumption per head, salt is made mainly for local consumption; and only about 54,000 tons a year are exported to the adjacent parts of Orissa, the Central Provinces and the Native State of Haidarabad. From Bombay, on the other hand, about 70 per cent. of the salt produced is exported for consumption in British districts and Native States outside the Presidency.

Much, if not most, of the salt made in both Presidencies contains 15 per cent. or more of magnesic salts, moisture, dirt and other impurities. The manufacture of salt by the evaporation of sea-water by solar heat may be a very crude process, and may also be a skilled industry; and up to the present in India it has not been found practicable to produce first-class sea-salt. But where the two kinds of salt meet in competition, Bombay salt is preferred. For many years Bombay salt has been sent by sea to Malabar; but, in or about 1890, after the construction of the Southern Mahratta railway, it displaced Madras salt in the Native State of Mysore and the Deccan districts of the Madras Presidency. The superiority of Bombay salt appears to be due partly to natural advantages and partly to a difference in administrative methods.

In Bombay, with the exception of some Government works at Dharasna in Gujarat, all the important sea-salt works are concentrated in the vicinity of Bombay.

The works are in creeks, where they are protected from the sea; and are mostly below the level of high tides, so that the reservoirs and pans can be filled by flow, and very little lifting of the brine is necessary. In Madras the works are scattered along the East Coast from Ganjam to Tinnevelly; and there are wide differences between the works in the matter of climate, soil and brine supply. Uniformity of treatment is, therefore, impossible. The coast line does not appear to be specially suited for salt manufacture. The soil in many places is sandy, and it is difficult to prevent sand from being scraped up in the pans in admixture with the salt. Much lifting of the brine also is necessary; and this does not conduce to the manufacture of good salt.

In neither Presidency is there a separate Salt Department. In Bombay salt is combined with Customs and Excise. Until 1917-18 there was a Collector of Salt Revenue; but the Collector had certain Customs and Excise duties to perform. The appointment has now been abolished: the Commissioner of Customs, Salt and Excise has been placed in direct charge of the production and distribution of salt: and the Excise and Salt staffs have been amalgamated. In Madras there is a combined Excise and Salt Department.

In Bombay, except at Dharasna, the manufacture of sea-salt is a private industry carried on under license; and the functions of Bombay Salt Officers are confined to seeing that salt made is properly stored, and that duty is paid before it is removed from the store. The manufacturers, many of whom are capable business men, are allowed to manage their works in their own way: the salt made is their property; and the prices at which it is sold are fixed by them with the purchasers without Government interference. In Madras, on the other hand, the Government take a direct part in manufacture. For many years there was a complete Government monopoly of the purchase and sale of salt. Then for a few years manufacture under a system of Excise was tried. This was held to have failed: and a conjoint system of Monopoly and Excise was introduced in 1888. At some works salt is made under the supervision of Government officers for sale to the Government. At others it is made and sold by private individuals on payment of the fixed duty. After some years at some of the works a system of modified Excise was introduced. Under this system a licensee is permitted to make salt for sale, but the Government has the option of purchasing the whole or part of the salt manufactured at a specified price. There are, therefore, three different systems at work at the same time. The Government and the Board of Revenue have made many attempts to improve the quality of the manufactured salt, but their efforts have not up to the present been very successful. A combined Excise and Salt Department is not well qualified to handle the subject. It is impossible to expect an officer, who has been employed upon Excise work in the interior of the country during the best years of his life, to develop into a salt expert when he is placed in charge of factories on the coast; and in a combined Department cases of this kind must frequently happen, even if they are not actually the rule. The association also of salt with Excise has resulted in unnecessary preventive zeal; and manufacturers are hampered in their business and the quality of the salt manufactured is impaired by the unnecessary stringency of the regulations enforced to protect the revenue.

It is remarkable how little Indian-made salt is sent to Calcutta for sale, though Bengal is now supplied mainly with sea-salt made in other countries. For many years some salt has been sent from Bombay to Calcutta, but the trade shows no tendency to expand. In the three years ending 1873-74, the average annual export was 16,000 tons; at the beginning of the war it was 34,000; and in the three years ending with 1922-23 it was 21,000 tons. In the past two years 38,000 tons of Madras salt have been exported (mainly, if not entirely, from Tuticorin) to Calcutta. In the south of the Presidency, where there is a long manufacturing season, it may be possible to produce salt suitable for the Calcutta market.

The Punjab Salt Range ranks next to Sambhar as the most important salt source in Upper India; and potentially it is perhaps the most important, as the supply of salt which it contains is practically inexhaustible. The Mayo mine at Khewrah, from which the great bulk of the salt is excavated, is one of the largest salt mines in the world; and 800 men, women and children are at present employed in connexion with it. The average annual output

of Punjab rock-salt in the five years ending with 1921-22 was 155,000 tons; and 85 per cent. of this came from the Mayo mine. The mine is on the site of old Sikh workings, and, for some years after the annexation of the Punjab, salt was excavated by haphazard methods, as it had been in the time of the Sikhs, without either technical knowledge or any clear idea of the lie of the salt. But in or about 1871 Dr. Warth, a German chemist and geologist, whose services had been secured by the Government of India, was posted to Khewrah. Dr. Warth had some knowledge of salt-mining in Germany; and, in 1872, he prepared the plan upon which the mine has since been worked. I have not been at Khewrah for at least 14 years; but the following description of the working plan is, I think, substantially accurate. The dip of the salt seams is, approximately, from north to south; and the strike is from east to west. The hill is divided into alternate sections of 40 feet and 25 feet along the line of the dip. The 40 feet sections are the working blocks and the 25 feet sections are the pillars by which the hill is supported. The main entrance of the mine is a tunnel driven into the hill from east to west, at a right angle to the dip, until the salt is reached. The salt is excavated in large chambers, along the dip, in the 40 feet sections, until it is worked out. No excavation, except tunnelling and shafts for ventilation, is permitted in the 25 feet pillars. The workings have been enormously extended, and the salt has been attacked from tunnels driven parallel to and at a lower level than the main entrance; but I think that I am right in saying that all workings are governed by the same broad principles. The excavated salt is brought from the workings to tram-lines in the tunnels, and is stacked there at convenient centres in wheeled trucks. These are dragged to the mine mouth, and from there are run down to the depot at the railway station on tram-lines. In former days the mining was done by men, and the salt was carried by women up the slippery pathways by the sides of the chambers to the tram-lines. Now a haulage engine, driven by compressed air, is used to lift the salt to the tramways; and light locomotives have taken the place of mules to drag the trucks to the mine mouth.

The mantle of Dr. Warth descended upon Mr. Bolster, an Irishman, who went to India as an usher in a school, and who exchanged the profession of teacher for a post in the Salt Department. He learnt how to use a theodolite and to make surveys and plans of the workings, and he acquired a sufficient practical knowledge of building to be able to supervise without any professional assistance the construction of masonry lining for the tunnels in the mine and of houses for the European staff. For 30 years, with one short interval, when he was employed at Sambhar, he managed the mine as Superintendent and as Assistant Commissioner in charge of the Division with great skill and with unwearied enthusiasm. The heat at Khewrah in the summer is very great, and I think I am right in saying that in the whole of his long service Mr. Bolster did not once have long leave.

Another mine is worked at Warcha to the west of Khewrah; and a third mine has recently been opened at Kalabagh on the right bank of the Indus, where the salt lies near the surface, and has been quarried from the time of the Emperor Akbar. These, however, are merely subsidiary sources of supply.

Kohat rock-salt is also found in enormous quantities on and near the surface; but it is inferior in purity, appearance and flavour to Punjab rock-salt, and is also more distant from the markets. It is, therefore, practically of no use for the supply of Northern India cis-Indus. About 22,000 tons of this salt are excavated and sold annually in the trans-Indus territory.

The Sambhar salt lake is situated in a depression in the schists of the Aravallis. When the lake is full the length from east to west is about 20 miles, and the width from 1½ to 7 miles. In the hot weather, in a normal season, the lake dries up or recedes to a shallow pool in the centre. Under Native rule, and for some years after the lake was leased, surface brine only was used; and the manufacture of salt was entirely dependent on the character of the season. Manufacture commenced as soon as the weather permitted, and ceased when the brine receded so far that it could no longer be conveyed to the pans and kyars on the edges of the lake in the small channels, which were constructed annually for the purpose in the bed of the lake. At this time large quantities of salt formed spontaneously in the lake bed. To facilitate this formation, the surface brine was held

up in suitable places near the storage grounds by low enclosing walls, made annually of grass and mud; and within these enclosures the salt was deposited. As recently as 1894 the quantity of salt manufactured in this way in a "fair average year" is said to have been 37,000 tons at least. This "Lake salt," as it was called, was inferior to the salt made on the edges of the lake in pans and kyars, but it was good edible salt.

"Pan salt" is made by professional salt-makers in shallow evaporating pans, constructed on the edges of the lake from the lake mud. These salt-makers contract to supply salt to the Department, and the salt is sold by the Department to the public. In former days the pans were filled with surface brine, but in recent years subterranean brine, obtained from pits dug by the side of the pans, appears to have been commonly used. "Pan salt" is good, but is inferior to "Kyar salt," as it is small in grain and the crystals are less perfect.

"Kyar salt" is made under direct Government management by workmen employed and paid, until recently, by Government officers. Contract labour has now, I understand, been substituted. A kyar consists of several deep evaporation pans, which are protected from the lake waves by walls or embankments of rough masonry and mud. Brine is admitted to the pans to a depth, usually, of about 15 inches, and is slowly evaporated by solar heat. After extraction of the salt, the bittern from the pans is run back into the lake. Kyars are said to have been in use when the lake was leased, but this form of manufacture has been much developed since the lake has been under management. "Kyar salt" is superior to "Pan salt," and the outturn is more certain. The tendency at present, therefore, is to rely more and more on the kyars. In 1921-22 Kyar salt formed 85 per cent. of the total outturn.

A serious defect of Sambhar has been the precariousness of the supply. In 1892-93 the monsoon rains were heavy, and the weather in the manufacturing season which followed was unfavourable. The total outturn of salt was, therefore, 3,300 tons only. In 1884-85 also there was a flood, and the outturn was 14,000 tons. On the other hand, in 1883-84, which was a favourable year, the outturn amounted to 263,000 tons, and most of this must have been lake and pan salt.

To fill the kyars in a season of short rainfall pumps have been used for many years; and, since 1906, subterranean brine has been extensively used to supplement the surface brine. When the shortage of salt occurred during the war, important measures were taken to increase the outturn of Sambhar. Brine reservoirs were constructed at both ends of the lake: and to ensure the maintenance of the brine supply at the eastern end, which is the more productive, a dam has been constructed across the lake from north to south at a cost of £36,000. Low-lift pumps have been obtained from Europe, and to work the pumps the Settlement has been electrified. The arrangements for loading and transporting the salt by railway from the lake have also been much improved. The methods of manufacture have been revolutionised. The effect on the productiveness of the lake and on the quality of the salt remains to be seen.

Sambhar salt contains 95 to 97 per cent. of chloride of sodium. It is not as pure as Punjab rock-salt, but is preferred to it throughout a large area in Upper India. The outturn of the lake at present is about 200.000 tons a year.

Didwana and Pachbhadra are worked as subsidiary sources to Sambhar. The popularity of Sambhar salt is so great and the cost of manufacture so low, that, if it were sold at cost price, the Didwana and Pachbadra sources would be destroyed. Sambhar salt is, therefore, sold, above cost price, at 4 annas a maund, and the other salts are sold below cost price: Didwana at 2 annas and Pachbhadra at 1a. 6p. per maund. The profit on Sambhar covers the loss on the other salts. At both these sources salt is made entirely from subterranean brine. In the five years ending with 1921-22, the average annual outturn of Didwana salt was 14,900 tons, and of Pachbhadra salt 33,400.

The Kharaghoda works are a very important salt source. In the five years ending with 1921-22 the average annual outturn was 136,000 tons, nearly equal to the outturn of the Punjab mines. The salt is made entirely from subterranean brine, obtained from wells sunk in the shore of the Lesser Runn of Cutch. The salt is made by professional salt-makers, but the land is the property of the Government, and the salt is made for sale to Government at a fixed price. The method

of manufacture is peculiar. Only one pan is used. This is filled with brine to a depth of four or five inches, and, after exposure to the sun for some days, salt begins to form. This, however, is not extracted, but is broken up and raked over. Fresh brine is then admitted, and the process is repeated until the crop of salt is considered to be ready for extraction. This is usually in about five months' time from the date of commencement of manufacture. The salt is good, as the supply of brine is skilfully regulated so as to prevent the deposit of inferior salts. It forms in large hard lumps very free from moisture, and finds favour in places where there is a moist climate. It is known in the trade as Baragra. The works are laid out so as to facilitate the storage and transportation by railway of the manufactured salt; and the authorities of the Bombay Baroda railway have always taken a benevolent interest in the source.

The works in Sind, in normal times, merely supply salt for consumption in the province, but Sind as a source of supply appears to have great potential importance. The Moach Plain, about seven miles to the west of Karachi, on which the Maurypur works exist, is commanded by the sea, but the salt is not made from sea-water in the ordinary way, and the works appear to have been established on the Kharaghoda model. Embankments protect a portion of the foreshore between ordinary and spring-tide levels. At spring tides sea-water is admitted to this area and is allowed to sink into the sand. Pits are dug, and, the brine entering them, which is the sea-brine strengthened by leaching of the salt accumulated in the sand, is lifted and evaporated. Maurypur salt has a good appearance, with hard, well-formed crystals, very superior to any Bombay and Madras sea-salt that I have seen. There appears also to be no reason why sea-salt should not be made on the Moach Plain in the usual manner. Both the climate and the locality appear to be favourable.

In the Thar and Parkhar district adjoining Rajputana there are numerous salt lakes, and at two of these lakes there are large deposits of naturally-formed salt of great purity. Without a railway, however, these deposits cannot be utilised for export.

For more than 30 years the policy, which was adopted in the years 1876-81, was remarkably successful. Drastic measures had been taken, but the people throughout Upper India were supplied in exchange with salt of a quality far superior to that to which they had been accustomed; and, in many places, owing to the construction of railways, salt was much cheaper than it had ever been before, notwithstanding the high rate of duty that was in force. In 1889 a proposal to place all the Salt Departments under one head was considered by the Government of India, at the suggestion of the Secretary of State. It was seen to be a defect on the existing arrangements that the experience of one Department was not utilised in the others: and the equalisation of the salt duties and the importance of the revenue as a financial reserve of the Imperial Government were suggested as reasons in favour of the proposed arrangement. The Madras Government, however, urged strongly the inadvisability of depriving the Local Government of the control of the administration; the advantages of local management were held to outweigh the drawbacks involved in the existence of several different controlling authorities; and the proposal was not approved.

For many years there was no suggestion of any possible shortage of the supply. The rivalry between the different departments and the different sources ensured the issue of Government salt to the public at the lowest possible price. In some cases, owing to this rivalry, salt was sold below cost price, and revenue was needlessly sacrificed. This, however, was a small matter. As the population increased, the consumption of salt increased throughout India, and an increasing revenue was secured with such facility that an idea was not unnaturally created that nothing more remained to be done. Owing to the reduction which had been effected in Upper India in the price of good salt, the prevention of the illicit manufacture of inferior salt had become a matter of quite secondary importance; but in the past prevention had loomed large in the salt administration, and when the time came for some change in the administrative arragements, the supposed importance of prevention helped to obscure the issue. A salt tax, in so far as it represents the appropriation of a share of the profit of the producer, the transporter and the vendor, while the prices of salt are kept low by an efficient administration, is an excellent tax in an Oriental country. When poor people are prosecuted for making coarse and inferior salt for their own con-

sumption, a salt tax is oppressive. The Government had accepted direct responsibility for the supply of salt to a large and increasing population in Upper India: and, in 1902, when I had been in charge of the Northern India Salt Department for three years, I formed the opinion that the adequacy of the supply was not sufficiently assured. The Sambhar lake was the principal source of supply for the greater part of the United Provinces. The enthusiasm and devotion to duty of Messrs. Ashton and Lyon, who had held charge of the lake for many years, rivalled the zeal and devotion to duty of Mr. Bolster at Khewrah, and they had both had much experience of salt questions. Both these officers were decidedly of opinion that there had been a marked decrease in the productiveness of the lake. The disappearance also of the spontaneously formed Lake salt, which had been collected in large quantities as recently as 1892-93, was decidedly ominous. At this time it was an article of belief in the Department that first-class Sambhar salt could only be made from surface brine; and the possibility of working Sambhar, like Didwana and Pachbhadra, had not been considered. The matter was represented to the Government of India, and the Geological Department was requested to investigate the question of the origin of the salt and of the possibility of it becoming exhausted. While this investigation was proceeding, I put forward a proposal to place the arrangements for the supply of salt to Upper India upon a more satisfactory footing by the amalgamation of the Northern India and Bombay Salt Departments, and the formation of a strong Department, possessing special knowledge, and dealing mainly with production. A Committee was appointed in 1903 by the Government of India to consider and report on the matter. I had not at the time, and have not now, any doubt that the amalgamation of the two Departments would have conduced to greater efficiency in the administration of the competing salt sources and to the development of other possible sources of supply. Unless, however, the importance of the supply question was realised, there was much to be said for the view taken in 1889; and I failed to convince either my colleagues on the Committee or the Government of India that the importance of the supply question necessitated the proposed change. A majority of the Committee recommended that Sind, where there is a small local Customs and Salt Department, should be placed under the Commissioner of Northern India Salt Revenue; and the Government of India were disposed to act upon this recommendation. But the Bombay Government was so strongly opposed to the proposal that the matter was subsequently dropped. A recommendation, made by the Committee, that additional sea-salt works should be opened in Bombay, as the annual average production of sea-salt (290,000 tons) was not sufficiently in excess of the minimum annual sales (257,000 tons) to preclude the possibility of a shortage in the supply, was at first accepted by the Government of Bombay, and a site for the works was selected. But difficulties were experienced in finding lessees who would accept the required conditions; and, after the matter had dragged on for some years, a favourable manufacturing season in 1911-12, in which 438,000 tons of sea-salt were produced, caused the Bombay Government to change its mind and drop the project. The existing works could, it was thought, produce without difficulty in an ordinary year 400,000 tons of salt; and the interests of the public might safely be left to the salt manufacturers and traders.

The investigation of the resources of the Sambhar lake, which was made by Mr. (now Sir T.) Holland, showed that there was no reason to anticipate any failure in the supply of salt from the lake for many years. Samples of silt, taken at regular intervals from the bed of the lake, were analysed by Dr. Christie of the Geological Department. From the results of these analyses it was estimated, in 1905, that in the upper 4 feet of the lake silt, over an area of 68 sq. miles, there was an accumulation of 18 million tons of sodium chloride, and that in the upper 12 feet there were 55 million tons. The disappearance of the salt, which formerly formed spontaneously in the bed of the lake, was ascribed to a rise in the level of the silt: and the broad conclusion arrived at was there was enough salt in the uppermost 10 feet of silt "to supply the requirements of this section of the Salt Department for 250 years."

The origin of the salt in the lake has formed the subject of much interesting scientific discussion. Put briefly, Sir T. Holland's theory is that the salt in Sambhar and in other depressions in Rajputana, is not derived from rock-salt deposits or from subterranean brine, but has been blown

in from the sea and from the Runn of Cutch in minute particles by the violent westerly winds, which precede the south-west monsoon, and that the salt, thus distributed over the country, is washed into the lake and other depressions by the feeder streams during the rains. The reasons urged in support of the theory are to me convincing; and the salinity of Sind and the south-west Punjab, which have no rock-salt deposits, and are similarly exposed to strong salt-bearing winds from the sea, appears to corroborate the theory.

Experiments made at Sambhar, after the investigation, showed that subterranean brine can be used in admixture with surface brine in the kyars, and that good saleable salt can be made from subterranean brine only. A failure of supply in a dry season is rendered less likely by this discovery.

For some years after this, the demand for salt in Upper India was adequately met from the Rajputana sources, the Punjab mines and the Kharaghoda works; and, so little was the possibility of trouble foreseen, that there was, as I understand, at one time some talk of abolishing the Northern India Salt Revenue Department.

The war completely upset the arrangements for the supply of salt to Bengal and Upper India. The annual imports of foreign salt at the beginning of the war were about 560,000 tons. English salt had been displaced to a great extent by salt made at Aden and on the shores of the Mediterranean by the evaporation of sea-water by solar heat; but the imports of English salt (133,000 tons) still exceeded those of any other kind. Aden imports, however, were not far behind, and the imports from the Red Sea, Port Said and Spain were also very large. For the first two years of the war imports were maintained. In 1915-16 they amounted to 525,000 tons, of which 120,000 tons were English. In 1916-17, owing to the shipping difficulty, they fell to 393,000 tons, and, in 1917-18, they fell further to 317,000 tons. The supply of German salt, which was about 5 per cent. of the total imports, was, of course, cut off. The imports of English salt did not entirely cease; but in 1917-18 they fell to 12,900 tons. The imports from Spain and the Red Sea ports also fell off; and a complete failure of supply was only prevented by an increase of the imports from Aden and Port Said. In 1920-21 the imports were large (595,000 tons); but in the four years from 1916-17 to 1919-20 there was a shortage in the imports of foreign salt of 693,000 tons, and the Salt Departments of India, disunited and imperfectly organised as they were, could not for two years do anything to make good the deficiency. To complicate matters, in Bombay and in Northern India the monsoon rains were heavy in 1916-17 and 1917-18; and a wet season is unfavourable for the manufacture of salt. The total production of salt in India in both these years (1,301,062 and 1,244,615 tons) was below normal; and it was not until the summer of 1918, when the very large quantity of salt (1,997,229 tons) made in that year came into the market, that the scarcity was to some extent relieved. The outturn of salt at Sambhar in 1916-17 amounted to 97,700 tons only, and in 1917-18 to 169,000 tons. In 1918-19, which was a favourable year, 426,000 tons of salt were manufactured. The output of the three years was, therefore, in excess of the average, which is now about 200,000 tons a year; but the partial failure in 1916-17, at the time of the greatest shortage, helped to create a panic. The other sources under the control of the Northern India Department maintained, but did not materially increase their production. Bombay was unable to render any assistance. At Kharaghoda in the four years from 1916-17 to 1919-20, the average annual outturn was 115,000 tons only, owing to unfavourable weather, a scarcity of labour, and to a severe outbreak of influenza in the miners' village in 1918-19. In 1919-20 the outturn was increased to 183,000 tons, but by this time the worst of the crisis was over. The sea-salt works failed badly. The decision not to open more works was wrong, and fate was adverse. In the six years ending with 1914-15, the average annual outturn of sea-salt was about 370,000 tons; but in the three years ending with 1917-18, instead of the 400,000 tons which it was estimated that the works could produce without difficulty in an ordinary year, the average annual outturn was 329,000 tons only. Bombay salt almost entirely disappeared from the Calcutta market.

Madras also gave no assistance. At the beginning of 1916-17 stocks in the Presidency were low, but strenuous measures were taken to increase the output and provide salt for Bengal. Large extensions of the salt-works were sanctioned, and men of

substance were encouraged to enter the business: and, in 1918-19, the enormous total of 631,000 tons of salt was manufactured. But the inferiority of Madras salt made it unacceptable in the Calcutta market, even when the scarcity of foreign salt was at its height; 11,000 tons of Madras salt reached Calcutta in 1915-16 and 14,000 tons in 1916-17; but in 1917-18 the imports fell to 5,000 tons, and in the next two years they ceased altogether. In 1917-18 Madras salt is said to have fetched in Calcutta only half the price of Aden and Port Said salt. This failure of the attempt to supply salt to Bengal appears to have opened the eyes of the authorities; and, in the annual report of the Board of Revenue for 1920-21, some of the reasons which have hitherto prevented the production of good salt in Madras are stated with great frankness and cogency.

As was natural in the circumstances, the prices both of foreign and Indian salt rose enormously, and the rise in prices extended to Bombay and Madras, although there was not at any time in the south of India any serious shortage of salt. Wild speculation took place in indents for salt from the Northern India and Kharaghoda sources. At the beginning of 1918-19 duty and price had been paid to the Government for 474,000 tons of salt from Sambhar and 259,000 from Khewrah in excess of the supply which was available. One speculator paid in Rs. 3,000,000. A salt tax is an iniquitous impost, but to make money out of the public by the exploitation of a monopoly is legitimate commercial enterprise! The system of sale from the sources direct to the public, which had been worked so successfully, completely broke down. Most strenuous measures were taken by the Government under the Defence of India Act for the protection of consumers; but the scarcity and dearness of salt in Upper India must have caused much inconvenience and hardship.

In Bombay vigorous measures were taken by Sir G. Lloyd's Government to increase the production both of Baragra and sea-salt. The development of the proposed new sea-salt works was ordered in 1917: difficulties with licensees were overcome, and the construction of works calculated to produce eventually 74,000 additional tons of sea-salt was commenced in the following year. Projects also were sanctioned for increasing the outturn of Kharaghoda and of the Government sea-salt works at Dharasna by 50 per cent.; and the remuneration of the Kharaghoda salt-makers was increased, and the conditions under which they live were improved, so as to prevent in the future the shortage of labour, which in the years from 1916 to 1918 had so much hampered the production of Baragra salt.

The salt-makers were the only people in India who benefited by the shortage of salt. The remuneration of these people had not been increased in proportion to the rise in prices which has taken place in India in recent years. A saline tract is an arid and disagreeable place, good water is often very difficult to obtain, and the occupation is by no means an easy one. Their remuneration has now been increased, and the necessity for supplying them with good water and for improving their conditions of life appears to have been generally recognised throughout India.

As regards the supply of salt in the future, the measures taken by Sir G. Lloyd's Government in Bombay appear to be very judicious, but, in my opinion, real efficiency cannot be secured without much greater specialisation in the matter of production than has hitherto been considered necessary. A supply of salt which was sufficient in 1881, for a population of 253 millions, is obviously inadequate for a population of 318 millions; and it is not desirable that India should be dependent to so great an extent upon foreign salt. From "India in 1923," by Professor Rushbrook Williams, it appears that the Government of India propose to provide against any possible failure of supply in Upper India in the future by doubling approximately the annual output from the Punjab mines and Sambhar; and, so far as the mines are concerned, the wisdom of this policy cannot be questioned. As regards Sambhar, however, the case is not so clear. The measures which have been taken will probably make it possible to increase largely the annual outturn of salt at the lake, but is it wise and is it fair to the Darbars, to whom Sambhar belongs, to work the lake to an extent which may cause a diminution of the supply, or a serious deterioration of the quality of salt, if other sources can be found which will provide a substantial share of the quantity of salt annually required in Upper India? There appears to be some misconception as to the

result of the investigation of the resources of the lake, which was made in 1902-5. Sir George Watt, in the "Commercial Products of India," published in 1908, says that the Records of the Geological Survey for 1905 contain a "highly instructive refutation of the opinion that the supply from Sambhar was decreasing;" and Mr Fergusson, the Commissioner of Northern India Salt Revenue, in the annual report of the department for 1917-18, says that the investigation "demonstrated the groundlessness of the apprehensions that the supplies of salt might be becoming exhausted," and accepts without question the view that the disappearance of the spontaneous salt is due to a rise in the level of the silt. A little salt is brought into the lake every year during the monsoon by the feeder streams, but the quantity brought in cannot compare with the quantity taken out. The supply of salt is, therefore, certainly decreasing, and the question is: Is it decreasing at a rate which may become dangerous? Personally, I am quite unable to admit that the inflow of silt, which is supposed to have been responsible for the disappearance of the spontaneous salt, can have been anything more than a contributory cause of it. The Menda, which is the principal feeder of the lake, runs through sandy soil, and has, from time immemorial, discharged enormous quantities of sand and silt into the lake. The circumstances of the past 30 years have not differed materially from those of previous years, and spontaneous lake salt was collected in large quantities as recently as 1892-93. The disappearance of this salt is, in my opinion, mainly, if not entirely, due to the fact that there is less salt than there was in the uppermost layer of the lake silt. It has, however, been demonstrated that good salt can be made in the lake from subterranean brine, and unless the brine deteriorates the manufacture of salt at Sambhar from subterranean brine can apparently be carried on indefinitely at Sambhar, as it is at Didwana and Pachbhadra. This, however, is a point which needs careful investigation. Sambhar brine contains sulphate and carbonate of soda in addition to chloride of sodium; and if the percentage of these salts increases beyond a certain point Sambhar salt will be spoiled. The chloride of sodium is taken out in large quantities, and the sulphate and carbonate of soda are, as far as possible, left in the lake. In 1904 Sir T. Holland arranged to have samples of the lake brine taken from different places in the lake periodically analysed and the results averaged in five-year periods. An analysis of the samples for 1907-11 and 1912-16 has been completed by Dr. Christie with the following result:—

LAKE BRINE.

	Cl.	SO_4	CO_3
1907-11 mean	86.09	9.94	3.97
1911-12 „	85.38	10.84	3.78

SUBTERRANEAN BRINE.

	Cl.	SO_4	CO_3
1911-12 mean	83.18	12.32	4.50
1911-12 „	81.07	13.88	5.05

In the words of Mr. Pascoe, the Director of the Geological Survey, from the point of view of the salt manufacturer the results show a deterioration, the lake brine and the subterranean brine both having at the end of the period a lower percentage of sodium chloride in the dissolved salts than they had at the beginning. An analysis of lake brine made by Dr. Warth in 1869-70, showed the following percentages:—Cl. 90.1; SO_4, 8.1; CO_3, 1.7. Too much reliance cannot be placed upon this analysis of an isolated sample; but the figures appear to show that the chloride of sodium in the brine is decreasing and the sulphate of soda, which is a serious impurity, is increasing. The figures are not conclusive, but they indicate the necessity for caution; and, if analyses made in future years show that the deterioration of the brine is continuing, the question of obtaining part of the supply of salt for Upper India from other sources will have to be seriously considered. The possibilities of Sind as a source of supply appear to be worth careful investigation.

The Government has made itself responsible for the supply of salt to Upper India, and is also indirectly responsible for the supply of salt to Bengal; and the present state of affairs cannot be regarded as satisfactory. The formation of a strong Salt Department, possessing a specialised staff, capable of dealing with the technical aspects of the subject, and concerning itself only with questions of production and distribution, appears to be necessary. Experts can watch and prevent the exhaustion or deterioration of existing works, and can apply themselves to the discovery and development of other sources of supply. Any preventive work that may be necessary may be left to the Provincial Excise estab-

lishments; but, if an adequate supply of good salt at reasonable prices can be assured, I think myself that the penal provisions of the law may be radically altered, and that the manufacture of inferior salt for domestic consumption need no longer be treated as a criminal offence. If this change in the law be made, the salt revenue, which is one of the most reliable of the financial resources of the Government of India, will no longer be open to attack.

DISCUSSION.

THE CHAIRMAN (Lord Meston), invited discussion on what he described as a lucid and exhaustive paper. He said that on looking at this little-known subject there were a considerable variety of topics which emerged. One topic which would probably interest many of the hearers or readers of the paper was the question of the taxation of salt. This was now becoming somewhat of the nature of a political rather than a fiscal question, but he hoped the taxation of salt would keep its proper place in the financial resources of the country. The handling of that particular tax would be one of the many tests of the financial efficiency of our Indian statesmen. Others who had listened to the paper would be interested in the problem which the question of salt presented to the Indian Government, the problem, namely, of reconciling the habits of the people with the necessary rigour of financial measures. It was a problem familiar to many of them in connexion with forests and other matters. Others might probably think—those, at least, who had visited India as sightseers—of the picturesque aspect of the salt question. Those who had seen certain of the salt mines would agree that there were few things more wonderful in nature than the spectacular resources of those subterranean chambers. Persons of a more serious disposition would probably turn to the way in which a vital industry in India had been managed by British officials from the earliest days of the East India Company to the present moment, the manner in which the early British officials had to feel their way, without expert knowledge or business experience, in the establishment of a great commercial proposition. The author had brought back many memories when he talked about the old Salt Customs hedge. He remembered himself stumbling across this hedge, a long stretch of thorny cactus and other growths running for two thousand miles across India, one of the most extraordinary relics of archaic administration which survived at the present moment. It seemed a long way from the Indian salt hedge to the scientific methods of administration for which Sir Richard Dane had been so largely responsible, and for the further improvement of which he was pressing, so rightly and properly, in the paper that evening. Another aspect of the question was the need for further and more enlightened handling of this little-known subject. That, indeed, was the chief lesson to be drawn from the interesting paper—the necessity for further scientific research into the handling of the great salt monopoly, so as to redeem the moral obligation which had been incurred by the British Government. The British Government had taken upon its shoulders, for good or evil, very largely under the pressure of stern financial reasons, the monopoly of the provision of salt for the people of India, and it had thereby a serious and permanent liability. It had a liability to protect the interests of the legitimate producers of salt in the country, and, what was even more important, it had a very heavy liability with regard to three vital services. The first of these services was the supply to the people of India of the cheap, good and abundant salt, which, as they all knew, was one of the most imperative necessities of life of the simplest and humblest peasant. In the second place, there was the necessity for providing an abundant supply of salt for the cattle of India, an aspect of the question far too often overlooked. In the third place, it was necessary to provide a sufficiency of proper salt as the basis for many of the great commercial industries—industries on which the future of India's prosperity very largely depended. With regard to this last aspect of the question, a gentleman had been present at that meeting only a few moments ago—unfortunately he had had to leave early—who was one of the greatest living authorities, namely, Sir Thomas Holland. Some of his manifold duties had called him elsewhere, and Sir Thomas was unable to initiate the discussion, but he had been good enough to leave the notes of what he had intended to say with Sir Reginald Mant.

SIR REGINALD A. MANT, K.C.I.E., C.S.I., read the contribution from SIR THOMAS H. HOLLAND. Sir Thomas was, he wrote, tempted to comment on many sections of this important paper, with most of which he cordially agreed; but in the time at his disposal his remarks must be limited to the one or two sections in which, with respect, he thought Sir Richard Dane's views merited limited qualification. The subjects with which he (Sir T. Holland) had been personally concerned most intimately were the Sambhar Lake and the Salt Range mines.

Sambhar Lake practically dried up every year, but when it became flooded in each rainy season, the water dissolved out from the silt of the lake-bed below—(1) sodium carbonate in small quantities, (2) sodium sulphate in larger quantities, and (3) sodium chloride, or common salt in still larger proportions. As this solution, or lake brine, was evaporated, the saturation point for the chloride was reached first, and continued evaporation then resulted in the precipitation of clean salt, until the brine reached the saturation point also for the sulphate, when both chloride and sulphate separated together. Thus, to obtain good marketable salt, the process of concentration was stopped when the saturation point for sulphate was being approached. The mother-liquor or

bittern, which still contained much salt, as well as the whole of the other sodium compounds, was then drained off and thrown into the lake. In this mother-liquor the ratio of chloride to other sodium compounds was approximately in the ratio of 65 : 35, whilst in the normal dilute lake-brine the ratio of chloride to other sodium compounds was now approximately 86 : 14. With the existing system of manufacture, therefore, the amount of salt obtainable from Sambhar was that surplus which, on removal, would reduce the ratio of chloride to other sodium compounds from 86 : 14, as it was now, to 65 : 35, when manufacture must stop. Obviously, the annual manufacture and removal of about 200,000 tons of salt was gradually lowering the ratio of 86 : 14, and the problem before Government was to estimate the speed at which this degeneration was going on. According to a single analysis made in 1870 the ratio of chloride to other sodium compounds was then 90 : 10; so that a degeneration of just 4 per cent. had followed the removal of over 6 million tons of salt in about 50 years. With variations in the rainfall, slight variations occurred in the composition of the lake-brine; hence the single analysis made in 1870 could not be trusted as accurately representing the state of the lake at that period. If analyses of the average lake-brine had been made regularly after Government took over the lake in 1870, it would have been possible by now to state exactly the rate of degeneration in the composition of the brine; but it was only after he took up the question, nearly 20 years ago, that systematic annual sampling was instituted. Politics permitting, this work would now be continued, and a few years hence it would be possible to estimate precisely the residual resources of Sambhar. The most reliable figures available so far were those due to analyses made by Dr. Christie, of the Geological Survey, between 1907 and 1916. Comparing the average for one five-year period with that of the next, they got a degeneration of 0.7 per cent. of chloride following a removal of just one million tons of salt. If the rate of degeneration were absolutely uniform, and if no change in the method of manufacture occurred, the end of Sambhar as a source of salt would occur when they had removed another 30 million tons, or, at the present rate of output, in another 150 years. Obviously, however, manufacturing troubles would increase as degeneration proceeded, and would become serious long before they reached the limiting ratio of 65 : 35. Even, however, if manufacture stopped when the ratio of 75 : 25 was reached, there would still be 16 million tons of salt obtainable; but to translate the quantity into time, an allowance must be made for the gradually increasing speed of degeneration as the ratio became lowered. The exact number of years was not very important, for, judging by the recent progress of political evolution in India, other changes far more serious—for good or ill—would precede the exhaustion of Sambhar. He would not confuse this obviously rough estimate by discussing the effect of additional salt inflowing annually with the tributary rivers, or of the further contributions from the salt now stored in the deeper layers of silt below the lake-bed. It was sufficient to show that there was no present cause for panic about Sambhar; there was plenty of time to consider other ways of meeting the growing demand for salt. Nevertheless, he agreed with Sir Richard Dane in urging the necessity for studying the situation very seriously; for the responsibility resting on Government was a heavy one.

In 1920 new works were started at Sambhar, and what he hoped was an improved system of manufacture was inaugurated in 1921. Sir Richard Dane placed on him the responsibility for this new system. The responsibility might be his but the credit for the idea and for its execution was due to a Public Works Officer, Mr. Bunting, whose services he (Sir T. Holland) borrowed in 1919. He was not afraid of the responsibility; for the capital spent on the new works had already been nearly recovered by improved returns. They had yet to show, however, that the system was foolproof, and, if the Government resumed its old policy of regarding salt-manufacture as a non-technical occupation, suitable for an underpaid staff, the new system would certainly be exposed to a severe test in the near future. But if worked intelligently, the reforms at Sambhar would secure the following among many obvious advantages:—(1) The newly enclosed area covered a part of the lake into which no river entered, and loss of depth by inflowing silt would thus be negligible. (2) The process of manufacture would be continuous instead of intermittent, thus giving the same outturn on a smaller evaporating area, with consequent saving in the cost of re-making pan beds, as well as a reduction of other expensive forms of maintenance. (3) Manufacture could be carried on at a uniform rate from the end of one rainy season till the commencement of the next, without dispersal of the labour in a dry year when, through famine, the men wanted work, and without the difficulty of assembling them again in a good agricultural year, when they did not want to come. (4) The works being less scattered, the cost of assembly of the salt would be reduced, and a centrally-situated, large, covered store would facilitate the despatch of indents, besides having many other obvious advantages.

Some of those who feared the early failure of Sambhar had regarded the new system of organisation as likely to hasten the end; but uniformity of annual output did not mean more rapid exploitation. Within limits the new system could be expanded or reduced to suit requirements, and could thus be relied on to meet one of the troubles to which Sir Richard Dane had referred, as a consequence of the curtailment of foreign salt supplies during the war, namely, temporary shortage and consequent local profiteering by traders. Hitherto Sambhar had been the victim of a variable monsoon, and its annual output had been alternately very large and embarrassingly deficient, varying from under 4,000 to over 400,000 tons.

The only person who had scored through these vagaries was the trader, whose activities at the expense of the consumer had put into the shade the so-called hardships of the salt tax, which he and others joined in condemning on the false assumption that it was a British innovation, instead of an inherited custom from Moghul times.

He had not referred to the manufacture of sodium sulphate as one of the advantages that should follow the new system of manufacture at Sambhar, because this advantage would not actually follow unless Government employed decently-paid technical officers for an obviously technical job. The sodium sulphate was now returned to the lake with the bitterns, and naturally increased proportionately each year, but its separation and profitable sale as a bye-product would enormously prolong the life of the lake as a source of common salt, by postponing the time when the embarrassing ratio of 75 : 25 will be reached. In the laboratory the separation of sodium sulphate from the Sambhar residual bitterns was perfectly simple, but in practice on a large scale it required abundance of water at the right time during the cold weather, and that had not been possible hitherto. The new system would provide the necessary conditions for translating laboratory practice into operations on a commercial scale, but technical management would be necessary, and it was unwise to place reliance just now on the probability that that desirable improvement would occur.

He did not agree at all with the suggestion that the exploitation of Sambhar, with consequent reduction of its accumulated stocks of salt, was in any way unfair to the States of Jaipur and Jodhpur, from which the lake had been leased by the Government of India. The Government, in exploiting the lake, did not attempt to make profit out of the sale of salt; their revenue was obtained from the tax, which they could charge just the same, whether the States retained the lake and sold the salt themselves in British Indian markets. As to the relatively small amount of salt that might be wanted in the future, for consumption within the two States, Sambhar would continue indefinitely to produce more than both States would ever want. Whatever differences of opinion there might be about the ability of Sambhar to stand the present output of over a million tons in every five years, the lake would never be so exhausted as to be unable to provide the small amounts wanted by the people of Jodhpur and Jaipur, even if it were the only source of salt in Rajputana. Meanwhile, both States were enjoying the financial benefits of rents and royalties paid to them by the Indian Government on a generous scale.

In the Salt Range of the Punjab, Government had been kindly treated by Providence with enormous deposits of rock-salt, exposed for quarrying at the surface, and had been fortunate in finding officers like Messrs. Bolster and Reid, who had made up with common-sense and energy for the disadvantages of a non-technical training. The rock-salt deposit was, however, a "wasting asset," and it would be unwise to rely on the chance of obtaining a continuance of successful management by an underpaid staff, now that mining operations were becoming more complicated.

The strike among the miners in 1920 conveniently served the purpose of forcing his attention to the necessity of reforming the methods of mining. Like many other post-war strikes in India, that of the salt-miners was precipitated by extremist politicians, who, with characteristic incompetence, imagined that it would embarrass the Government. The absence of the men, however, for a few weeks enabled the Government to install machinery, which cost less than the savings in wages, and demonstrated the possibility of obtaining an increased output with a smaller labour force. The only embarrassment that occurred was in trying to find work for the miners when they wanted to come back.

It was obvious that the Salt Range could be developed to any reasonable extent to meet the wants of those areas within reach in which rock-salt was acceptable to the consumer.

Although there was little doubt about the large size of the Punjab deposits, each work required systematic forward development to permit of safe and economic mining operations. The employment of trained mining engineers as managers would ensure that this precaution, hitherto not systematically observed, would be taken in future.

Sir Richard Dane was anxious to remove the rigid restrictions on the local manufacture of earth salt—restrictions that were irksome, not completely effective, hard on the poorest classes, liable to abuse, and tending to divert the Department from their main object of production. The impression that he (Sir T. Holland) obtained seemed to indicate that in many places the cost of preventive measures was not worth the saving in tax, whilst it probably added to the burdens which were gradually killing the saltpetre industry. The restriction of manufacture to a few centres was also adding to the danger of the spread of *reh* in those areas that had an insufficient rainfall, with evaporation that exceeded the run-off. These areas now get their salt from outside, and what entered never left. Every ton of salt that entered areas of this sort added to the soluble salts that appeared gradually as a surface efflorescence, and spread like a disease over otherwise good agricultural land. The ultimate object to be aimed at obviously was a reduction of the salt tax, without necessarily its abolition. Any tax on a scale that increased the temptation to evasion brought the reaction which Adam Smith pointed out to be the inevitable consequence of heavy import duties in England at the end of the XVIIth century. However, that opened another and quite different story.

MR. WILLIAM MACNAB, C.B.E., asked what was the chemical composition of the salt ultimately obtained from the brine at Sambhar. It would be interesting to have that information, if the author could give it, in view of the fact that there was

so much sulphate of soda and carbonate of soda in the brine.

Sir John O. Miller, K.C.S.I., proposed a very hearty vote of thanks to Sir Richard Dane for the full account he had given of the administration of the Indian Salt Department, and also to the Chairman (Lord Meston) for finding time to preside over the meeting. They were all aware that there was perhaps no Indian official who knew so much about India as Sir Richard Dane, and he thought they had all been surprised, both at the width of his outlook, and at the knowledge of detail which he had shown in dealing with the subject which had occupied his later years in India. They were all quite satisfied that during Sir Richard Dane's management of the Department those responsibilities which the Chairman had enumerated as belonging to the Government of India were very seriously undertaken.

Lieut.-Colonel D'Arcy G. Bannerman, C.I.E., C.V.O., in seconding the motion, said he had had the honour and pleasure once of meeting Sir Richard Dane in the Native State of Rajputana, where he had gone to put a stop to infractions which existed in connexion with the salt agreement made by the Government of India. He knew how successful Sir Richard Dane had been in putting an end to that difficulty, and he also remembered how, directly his business was concluded, he expressed a desire to inspect the jungles of that State, and how successful he was in adding specimens of their fauna to his excellent collection.

The vote of thanks was carried unanimously.

Sir Richard Dane, in reply to the question about the quality of the Sambhar salt, said that all the figures had related simply to the composition of the brine. The matter was rather a difficult one chemically, because while common salt had practically the same solubility in cold water and in hot water, the solubility in the case of other salts depended partly on the temperature of the water. The proportion of chloride of sodium in the Sambhar salt produced was about 95 per cent. As he had said, there was undoubtedly a slight progressive deterioration of the brine, but he did not think that this could have seriously affected the composition of the manufactured salt up to the present. With regard to Sir Thomas Holland's remarks, on the main point he believed that Sir Thomas Holland and himself were in absolute agreement, namely, that the question of salt in India could hardly be allowed to run on in the more or less happy-go-lucky way that it had done for many years. And Sir Thomas Holland would agree with him as to the necessity for specialisation. If there had been a strong specialised Salt Department formed in 1904 the crisis which occurred during the war would have been more satisfactorily met.

NOTES ON BOOKS.

The British Trade Boards System. By Dorothy Sells. London: P. S. King and Co., Ltd.

About four thousand years ago, as the author tells us, there were Government regulations in Babylon defining "..the exact amount to be paid to workers in various occupations," (p. 1); but we may remark that in all periods of which we have detailed record, there has been periodical alternation between free or individual bargaining as regards wages, and legislative control of wages.

Even now with a generally dim vista of historical events and social organisations during six thousand years, we cannot find indubitable and unmixedly clear indications in favour of:— (a.) Completely free bargaining between individual employers and employed; (b.) Combination, and collective bargaining allowed on both sides; (c.) Definite governmental or departmental or plebiscital control of wages, with penalisation of those who disobey. Moreover, we do not know whether a fixed rise in wages is a real and effective increase, or a figment to which social conditions and prices tend to adjust themselves.

It may be well to remind our readers that the present-day Trade Boards are in reality wages boards of a class very extensively experimented with during the development of our country; these present-day Trade Boards are, however, based on recent Australian legislation, as detailed in a report (1907) by the late Mr. Ernest Aves to our Home Office; this report having been issued as a blue book. A good account of this important but much misunderstood incident is to be found on *p.* CVII of the British Supplement to the Bliss Encyclopedia, 1908 Edition, edited by Ed. Page Gaston. It is interesting to note (middle of Col. II), that Mr. Aves expresses doubts as to the desirability of establishing compulsory boards in Great Britain, and as to whether compulsory powers can be effectively exercised.

Thus it will be realised by our readers that the Trade Boards treated of in the work under notice are fundamentally different from the Permanent Industrial Court, as treated of by Sir William Mackenzie in a paper which appeared in the Society's *Journal* of May 11, 1923.

To the student of economics, the manufacturer, and indeed to every employer of labour, the work under notice may be of value as embodying a fund of inner facts as to the working of the present-day Trade Boards, facts gathered by personal observation (*Cf. e.g., p.* 219), or personally communicated details (*pp.*V—VI). In short, we find in this work just the kind of vital detail which is so often lacking in books on economics, and the book inspires the utmost confidence as to the accuracy of the facts. If, however, the facts had been linked together by laborious cross-referencing and a really good index the value of the work would have been much greater.

Two Acts of Parliament and a host of forms, schedules, and papers are more or less summarised in the dictum "The chief business of a Trade Board is to determine what the rates of remuneration shall be in its trade" (*p.* 17), but practical difficulties have arisen and "not infrequently a period of one or two years elapsed before the initial rates became operative" (*p.* 17). The "Grocery and Provisions Trade Board" had a troubled existence of more than two years without getting any rates confirmed," (*p.* 18). Further, "..It has not been an unusual occurrence during the past two years for a Board to propose to vary its rates at the same meeting at which those rates were fixed" (*p.* 18). The apparent insuperable difficulty of defining certain trades and of working on the overlaps, with the incident uncertainty as to which of various trade rates ought to apply runs through the book; but it may be sufficient indication of the difficulty to turn to *p.* 54 where we read of an official "definition" of the Grocery and Provisions Trade, which fills three printed pages.

Much trouble seems to have arisen from the fact that ordinarily a board is free to arrive at its rates by any procedure which it may choose (*p.* 54) and a somewhat remarkable instance of procedure is given on *p.* 219 as having come under the personal observation of the author. "This Board had lived through a most stormy existence, and had worn out two Chairmen in fixing its initial rates." A change was proposed and peace seemed hopeless, but one of the women having spied a box of cigarettes "which had been inadvertently left on the table by the leader of the employer's side," she seized it and distributed the contents, thus "bringing about a settlement without ill feeling." We find, however, no hint as to the equity, desirability or public utility of the settlement.

Apart from the definitely useful function of recording facts, a leading mental note or sense of the book appears to be of interest in many ingeniously set puzzles, and satisfaction when any settlement or conclusion is arrived at, but the real lessons of history seem to be entirely out of mind.

The keynote of the work under notice is post-war influence on wage rates, rent, and economic conditions. As a partial parallel we may refer to the incidents which preceded the oft-mentioned speech of Menenius (Rome about 494 B.C.) on "The belly and the members"; while the incidents which immediately followed this speech seem to indicate or foreshadow much which is embodied in modern Industrial Arbitration Courts and in modern representation. To understand the parallel, reference should be made to Webb's various notes on "Who is the real Landlord" (*e.g.*, *p.* 41 of The Practical Socialist for April, 1887). Also note should be made of the incredibly drastic laws as to debt in Rome at this period. (See *p.* 72 of Student's Rome, Liddell. 1872 Edition, Murray). In Florence, there was (1378-1380) a partial parallel with our present time; rival trade organisations and labour elements being in power, but reaction set in during 1381.

AUSTRALIAN WOODS FOR PULP AND PAPER MANUFACTURE.

During the last three years an investigation of the possibilities afforded by Australian timbers for the production of paper-pulp suitable for the manufacture of newsprint has been carried out by the Institute of Science and Industry of the Commonwealth of Australia, and the results have appeared in a paper entitled "The Manufacture of Pulp and Paper from Australian Woods," by L. R. Benjamin, which has been published in the *Bulletin of the Imperial Institute* No. 25 (1923).

It is estimated that during the next decade the annual demand for newsprint in Australia will reach 100,000 tons. At the present time about 120,000 tons of paper and pulp, of value £5,500,000, are imported each year, of which 70,000 tons consists of newsprint, 12,000 tons of other printing paper, 10,000 tons of wrapping paper, and 6, 000 tons of writing and typing papers, whilst about 5,000-6,000 tons of wood-pulp are imported for use in the Australian paper mills.

There are three paper mills and four board mills in Australia, all of which are situated in Victoria and New South Wales. The total annual output of these mills amounts to about 35,000 tons, comprising about 2,000 tons of fine paper, and 10,000 tons of wrappings, covers, etc., the remainder consisting of paper-board and straw-board.

No newsprint is manufactured in Australia, but there is a local market capable of absorbing the output of two paper mills, producing 100 tons of newsprint a day. The successful establishment of such mills depends on the possibility of obtaining large supplies of raw material from which suitable pulp could be produced at a cost of about £10 per ton.

The general conclusions drawn from these pulping experiments may be summarised as follows. The woods of the eucalyptus and most of the other woods examined contain, on the average, as great a percentage of cellulose as that of poplar, birch, spruce and other standard pulp-woods. In the case of the eucalypt timbers the fibres have a length of a little over 1 mm., and a diameter of one fiftieth to one-sixtieth of the length. The young wood is easily barked and chipped, and is to be preferred to mature timber, although in the case of *E. regnans* the mature wood can be pulped successfully without any variation in the conditions of digestion. Quickly grown wood is easily penetrated by the caustic alkali solution, and is rapidly converted into pulp.

The most suitable woods with regard to yield, ease of pulping, and bleachability of the pulp are the immature eucalypts of South-Eastern Australia, viz. *E. regnans*, *E. delegatensis*, *E. siberiani*, *E. globulus* and *E. obliqua*, although *E. pilularis*, *E. diversicolor* and *E. calophylla* give a larger yield per cord and a larger output per digester than these. The Queensland woods, with two or three unimportant exceptions, are not suitable for the

production of strong, easy-bleaching pulp by the soda process, but some of them, particularly *Aleurites moluccana*, *Tarrietia argyrodendron*, *Grevillia robusta* and *Callitris glauca*, can be used for the manufacture of kraft pulp. Indications were obtained that *Aleurites moluccana* and *Tarrietia argyrodendron* might give better results if treated by the sulphite process. On the whole, it is concluded that the eucalypts offer the most promising field for immediate exploitation.

The laboratory paper-making experiments, using a model Fourdrinier machine and a beater of 3lb. capacity, were carried out with five typical eucalyptus pulps, viz., those of *E. regnans*, *E. pilularis*, *E. maculata*, *E. dalrympliana* and *E. diversicolor*. It was found that these pulps differ from most hardwood soda pulps, as they can be hydrated without difficulty, and when hydrated are capable of forming paper of at least average strength. It is stated that eucalyptus pulps should not be regarded as mere fillers, for giving opacity and bulk, but as "half stuff," possessing considerable strength, and therefore generally useful as paper-making materials. Particulars are given of experiments carried out on a semi-commercial scale at the Barwon Paper Mill of the Australasian Paper and Pulp Co., Ltd., at Geelong. The results of the trials confirmed those obtained in the laboratory, and showed that the woods of the eucalypts are most efficiently pulped by a modification of the soda process, in which the chips are submerged in a weak liquor throughout the period of digestion, external heating being employed in order to avoid further dilution. By adopting this procedure, instead of direct digestion with strong liquor, the yield is increased by as much as 60 per cent. and the strength of the pulp is greatly improved. The eucalypts of Tasmania and Victoria and young karri (*E. diversicolor*) give the highest yield of pulp for equal weights of wood, and are the most easily bleached. The yield of screened pulp for the most important woods was between 45 and 47 per cent. All the woods give a higher yield per cord than either spruce or poplar.

The paper-making experiments showed that mixtures containing 60 to 70 % of eucalypt pulp are capable of furnishing paper of considerably higher bursting and tensile strength than those made almost entirely from spruce sulphite pulp under the same conditions. Moreover, papers made from mixtures containing about 60 per cent. of eucalypt pulp exhibit superior opacity and good finish. In the case of such papers there is less shrinkage during drying than with papers containing a large proportion of sulphite pulp. Well-prepared eucalypt pulps are suitable for many purposes, and specially for the manufacture of the better-grade printing, book, magazine and cartridge papers, and the cheaper grades of writing and typing papers.

The eucalyptus trees proposed as a source of pulp-wood reach a size suitable for cutting in from 8 to 15 years, whereas spruce and other pulp-woods require at least 40 years to grow to this size. Vigorous coppicing of the trees results in the production of dense stands yielding as much as 40 cords per acre in less than ten years of growth. Protection of the forest from fire would be relatively simple and inexpensive. The system of "river driving," which is commonly used for transporting timber from slow growing forests in which the area to be logged is situated farther from the mill each suceeding year, could be replaced in the rapidly growing forests of Australia by a permanent railroad logging system, as the average haul would be small, and the quantity of wood to be transported would be large. It is considered that the cost might be much lower than in many cases of "river driving."

Suitable labour is available in Australia for operating pulping plants, and the cost would not be any greater than in the United States.

In the States in which the greatest reserves of pulp-wood exist large power schemes are in course of development. Cheap hydro-electric energy is available in Tasmania, whilst in Victoria power generated from lignite at Morwell and cheap brown coal itself will be available in a year or two.

Estimates of the cost of production of pulp are given which are based on a small plant with a daily output of 10 tons of air-dry bleached-pulp. Under these conditions, and with fuel at 30s. per ton, wood at 40s. per cord, soda ash at £10 per ton, salt at £4 per ton, lime at 25s. per ton, power at 0.5d. per kiliwatt-hour, and a minimum wage of £4 5s. per week, pulp could be produced at a little less than £13 per ton. Under more favourable conditions and with a larger output, the cost might be reduced to about £10 per ton.

The simultaneous operations of saw-mills and pulp-mills would effect much greater utilisation of the forests than is now possible, and would assist the production of future supplies of mill timber, by providing a market for thinnings from cut-over areas undergoing silvicultural treatment. Moreover, a certain amount of mill waste could be utilised for pulping, in addition to most of the small and some of the defective trees.

It is considered possible that sufficient wood-pulp could be produced in Australia to supply the local paper-making industry with 6,000-10,000 tons per annum, and also to develop an export trade. A paper-mill designed to manufacture printing paper, and using 60-70 per cent. of Australian pulp and some imported pulp, would have the advantages of a supply of cheap pulp, the absence of high freight charges, and the operation of a protective duty on imported paper. A combined pulp and paper mill would offer even better prospects.

The conclusions reached by the investigations described in the *Bulletin of the Imperial Institute* are summarised as follows: (1) An abundance of wood in the form of young regrowth is available for establishing the pulping industry; (2) the wood is easily pulped by a modification of well-known pulping processes, the cost of production being low; (3) the pulp is suitable for a fairly wide range of papers; (4) conditions are favourable

for establishing a pulp-mill to supply at least 3,000 tons and possibly 10,000 tons of pulp annually for the local market, and an export trade is also possible; (5) there is little doubt that chemical pulp could be produced in Australia sufficiently cheaply to permit of its use in the manufacture of newsprint.

GENERAL NOTES.

A Tree Planting Machine.—Attention is drawn in the February number of *South African Journal of Industries* to a recent invention designed to facilitate the planting of trees. It is known as the Duivel Tree-Planter, and the principle on which it works is that of taking up the rich nursery soil around the young tree, with the tree in the centre, and planting the whole in the position which the tree is to occupy permanently. The roots are thus left undisturbed, and the tree suffers nothing from its change of position. The removal is accomplished by means of a cylinder which is placed around the tree and pushed down into the soil. By this means a young tree can be removed with a block of soil round its roots nine inches deep and nine inches in diameter. The cylinder is then planted in the designed spot and withdrawn. It is claimed that a young tree can be planted out with the Duivel machine in the hottest sun at any season of the year without suffering any serious setback.

Cattle Breeding in North Manchuria.—North Manchuria has large stocks of cattle, which however, do not reach outside markets, because the industry is but little organised, states the Bureau of Economic Information. The number of horses there and adjoining Mongolia exceeds 3½ million. The number of mules is also very considerable. Large horned cattle are estimated at five million head, whose productivity is excellent, and the meat highly valued for its taste. Pig-rearing is developed in the areas of intensive agriculture, and the total number of pigs reaches 3,200,000 head. The export of bristles, which are the main products of pig-rearing, averages 89-100 tons per annum. The yearly growth of the number of cattle, after providing for natural decreases, epizootics, etc., in the area gravitating to the Chinese Eastern Railway, may be determined as follows: Horses, 140,000; large horned cattle, 350,000; sheep, 1,100,000; pigs, 330,000. Theoretically, almost all might be brought to market, but not more than ten per cent. are. This is explained by absence of regular sales organisation; there are no refrigerators, no sorting arrangements, and neither credit nor capital is found to put the business on a proper standing.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings at 8 o'clock (except where otherwise stated):—

May 14.—F. C. Ingrams, President of the London Fur Trade Association, "Furs and the Fur Trade." Ernest Poland, Vice-President of the London Fur Trade Association, will preside.

May 21.—(Trueman Wood Lecture.) Sir William J. Pope, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, "The Outlook in Chemistry." Sir Herbert Jackson, K.B.E., F.R.S., will preside.

May 28 (at 4.30 p.m.)—Mrs. Arthur McGrath (Rosita Forbes), "The Position of the Arabs in Art and Literature." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Indian Section.

Friday afternoon, at 4.30 o'clock:—

Tuesday June 24, at 4.30 o'clock J. C. French, I.C.S. "The Art of the Pāl Empire in Bengal."

Dominions and Colonies Section.

Tuesday, May 27, at 4.30 o'clock.—C. Gilbert Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus."

Wednesday, June 4, at 4.30 o'clock.—The Rt. Hon. Sir Frederick Lugard, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member, Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates."

Monday, June 16, at 4.30 o'clock.—C. V. Corless, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, May 12 .. British Academy, King's College, Strand, W.C., 5.15 p.m. Dr. E. K. Chambers, "The Disintegration of Shakespeare."

Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Prof. E. Naville, "Deuteronomy a Mosaic Book."

Geographical Society, Lowther Lodge, Kensington Gore, S.W., 5 p.m. Captain G. T. McCaw, "The Proposed Adoption of a Standard Figure of the Earth."

Mechanical Engineers, Institution of (Graduates' Section), Storey's Gate, Westminster, S.W., 7 p.m. Engineer-Captain E. C. Smith, "The Makers and Making of our Modern Navy."

East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Mr. F. Wright, "The Sukkur Barrage Project, 1920."

Architectural Association, 34, Bedford Square, W.C., 8 p.m. Mr. Hakon Ahlberg, "Modern Swedish Architecture."

University of London, at University College, Gower Street, W.C., 5 p.m. Prof. G. D. Hicks, "Kant's Theory of Sublimity and Beauty." (Lecture I.)

At King's College, Strand, W.C., 5.30

p.m. Prof. J. A. K. Thomson, "The Art of Herodotus."

At Bedford College, Regent's Park, N.W., 5.15 p.m. Mr. A. Thibaudet, "Albert Sorel." (Lecture I., in French.)

University Extension Lectures, at Gresham College, Basinghall Street, E.C., 6.15 p.m. Mr. A. Compton-Rickett, "Personal Forces in Modern Literature." (Lecture II., Granville Barker.)

Meteorological Society, 49, Cromwell Road, S.W., 5.15 p.m. Prof. V. Bjerknes, "The Formation of Cyclones."

Brewing, Institute of, at the Engineers' Club, 39, Coventry Street, W.C., 7.30 p.m. (1) Mr. E. B. Collier, "Some Experiences in the Erection and Use of Concrete Vessels in the Brewery." (2) Mr. C. A. Finzel, "Note on a Dust-quenching Plant."

TUESDAY, MAY 13 .. Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. R. K. Richardson, "The Geology and Oil-Measures of South-East Persia."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m. Sir H. Denison, "Australia and the Pacific."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. C. P. Butler, "Photographic Record for Astrophysical Research."

Transport, Institute of, at the Institution of Electrical Engineers, Victoria Embankment, W.C. (Graduates' Section), 5.30 p.m. Annual General Meeting.

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. J. Barcroft, "Effect of Altitude on Man." (Lecture III.)

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. W. G. Constable, "The History of Decorative Painting in England." (Lecture III.)

At King's College, Strand, W.C., 5.30 p.m. Dr. Drazutin Sabotić, "The Second Reign of Prince Milos (1858—1860)."

At Bedford College, Regent's Park, N.W., 5.15 p.m. Mons. A. Thibaudet, "Albert Sorel." (Lecture II., in French.)

At the Imperial College, South Kensington, S.W., 5.15 p.m. Dr. W. G. Miller, "The Pre-Cambrian — with special reference to Ontario." (Lecture I.)

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. Annual General Meeting.

WEDNESDAY, MAY 14 .. Sanitary Engineers, Institution of, Caxton Hall, Westminster, S.W., 7.30 p.m. Dr. E. K. Rideal, "Some Physico-Chemical Factors in Water and Sewage Purification."

University of London, at the School of Economics, Clare Market, W.C., 5.30 p.m. Prof. C. G. Seligman, "The History and Present Position of the British Commonwealth—Racial Problems of the Empire."

THURSDAY, MAY 15 .. Royal Society, Burlington House, Piccadilly, W., 4 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Chemical Society, Burlington House, Piccadilly, W., 8 p.m. (1) Messrs. I. E. Balaban and F. L. Pyman, "The Bromo-Derivatives of 1-Methylglyoxaline and the Constitution of 'Chloroxalmethylin.'" (2) Messrs. R. Campbell and W. N. Haworth, "Synthesis of Amygdalin." (3) Messrs. R. G. W. Norrish and E. K. Rideal, "Re-activity and radiation. The Photochemical Union of Hydrogen and Sulphur."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Royal Institution, Albemarle Street, W., 5.15 p.m. Dr. E. V. Appleton, "Atmospheric Interference in Wireless Telegraphy." (Lecture I.)

University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. E. G. Gardner, "Contemporary Italian Novelties."

5.15 p.m. Prof. J. E. G. Montmorency, "The History of Diplomacy."

2.30 p.m. Prof. Sir Flinders Petrie, "Recent Discoveries in Egyptology."

At King's College, Strand, W.C., 5.30 p.m. Mr. Arundell Del Re, "English Influences in Italian Literature during the XVIIIth Century."

5.30 p.m. Prof. T. H. Bryce, "The Development of the Human Embryo up to the appearance of the Primitive Segments. (Lecture I.)

5.30 p.m. Prof. A. J. Toynbee, "Outlines of Byzantine, Near Eastern and Modern Greek (378—1841 A.D.)." (Lecture IV.)

Tropical Medicine and Hygiene, Royal Society of, 11, Chandos Street, Cavendish Square, W., 8.15 p.m. Professor Yorke and Dr. J. W. Scott Macfie, "Observations on Malaria made during the Malaria Treatment of General Paralysis."

FRIDAY, MAY 16 .. Engineering Inspection, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m.

Philological Society, University College, Gower Street, W.C., 8 p.m. Special meeting in honour of the Centenary of the Royal Asiatic Society. Contributions on African Languages.

Medical Officers of Health, 1, Upper Montague Street, W.C., 5 p.m. Prof. J. W. H. Eyre, "Public Health and the Oyster."

Geologists' Association, University College, Gower Street, W.C., 7.30 p.m. Mr. C. C. Fagg, "The Recession of the Chalk Escarpment of the North Downs, and the Origin of the Chalk Valleys."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Discussion on Third Report of the Steam Nozzle Research Committee.

(Yorkshire Section), Municipal Technical College, Hull, 6 p.m. Mr. N. McKenzie, "Belt Conveyors."

(Midland Section), Chamber of Commerce, New Street, Birmingham, 7.30 p.m. Annual Meeting and Informal Discussion.

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. D. H. Wilkinson, "The Masters of Landscape Painting."

University of London, University College, Gower Street, W.C., 5.30 p.m. Miss M. S. West, "The Old Testament." (Lecture I.)

At King's College, Strand, W.C., 5.30 p.m. Mr. W. Poel, "Some Theories about 'All is True,' a play which in 1612 caused the destruction of the first Globe Playhouse." (Shakespeare Association.)

5.30 p.m. Prof. T. H. Bryce, "The Development of the Human Embryo up to the appearance of the Primitive Segments." (Lecture II.)

At Bedford College, Regent's Park, N.W., 5.15 p.m. Mons. A. Thibaudet, "Albert Sorel." (Lecture III., in French.)

Royal Institution, Albemarle Street, W., 9 p.m. Very Rev. W. F. Norris, "The Stained Glass of York Minster."

SATURDAY, MAY 17 .. British Legion (Women's Section), at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 10 a.m. Annual Conference.

University of London, University College, Gower Street, W.C., 3 p.m. Prof. Sir Flinders Petrie, "Recent Discoveries in Egyptology."

Royal Institution, Albemarle Street, W., 3 p.m. Dr. W. G. Alcock, "How Music is Made."

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, MAY 21ST, at 8 p.m. (Trueman Wood Lecture.) SIR WILLIAM J. POPE, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, "The Outlook in Chemistry." SIR HERBERT JACKSON, K.B.E., F.R.S., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, MAY 7th, 1924; ADMIRAL OF THE FLEET SIR HENRY JACKSON, G.C.B., K.C.V.O., F.R.S., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Airth, George Rennie, London.
Broemel, Percy Rudolph, London.
Graham, Edward Alfred, Beckenham, Kent.
Webber, Henry O'Kelly, Johannesburg, South Africa.
Wreford, Ernest Henry, East St. Kilda, Australia.

The following candidates were duly elected Fellows of the Society:—

Fabini, H. V., Richmond, Surrey.
Gothard, H. A. S., Bickley, Kent.
Martynik, Jan, Gemsa, Egypt.
Sandell, H. W., North Shields.

A paper on "Wireless Navigation for Ships and Aircraft" was read by DR. J. ROBINSON, M.Sc., F.Inst.P., Head of the Wireless and Photography Department, Royal Aircraft Establishment, Farnborough.

The paper and discussion will be published in a subsequent number of the *Journal*.

VISIT TO THE GUILDHALL.

About seventy Fellows of the Society and their friends visited the Guildhall on Thursday afternoon, May 8th, in response to the invitation of MR. H. G. DOWNER, LL.B., a member of the Common Council.

They were shown over the Council Chamber, The Crypt, and other places of interest in the Guildhall by MR. DEPUTY ALDERTON, C.C.; SIR ALFRED GEORGE TEMPLE, F.S.A., Director of the Art Gallery of the Corporation of London, acted as escort in the Art Gallery, and afterwards MR. DOWNER entertained the whole party at tea.

At the conclusion of the visit a vote of thanks to MR. DOWNER was proposed by SIR JOHN O. MILLER, K.C.S.I., and seconded by COLONEL C. NAPIER SIMPSON, D.S.O., R.F.A.; a vote of thanks to SIR ALFRED TEMPLE was proposed by MR. NOEL HEATON and seconded by MR. C. T. COURTNEY LEWIS; and a vote of thanks to MR. DEPUTY ALDERTON was proposed by the SECRETARY and seconded by MR. F. J. TATHAM.

PROCEEDINGS OF THE SOCIETY.

SEVENTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 2ND, 1924.

LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair.

THE CHAIRMAN, in introducing Sir Lynden Macassey, said the subject of the address was, at the present moment, a very interesting, difficult, and also, he trusted, hopeful one. Sir Lynden and the audience had been able to notice during the last few days what happened to London when a considerable amount of traffic was stopped. He dared to say that if Sir Lynden had been pursuing his war-time activities, such as of Director of Shipping Labour, or dealing with the various difficulties of dilution of labour upon the Clyde, he might have been able to give some of the inner history of that difficulty; but, as it was, he hoped that it had enabled Sir Lynden to take some notes of what happened when part of the traffic of London was stopped, and also to compare it with what were the difficulties when the whole of the London traffic was in full swing.

There was no doubt that the subject was an extremely difficult one. There was seasonal traffic, race traffic, funeral traffic, sports and football

traffic, traffic at the rush hours, and traffic at different points of London which varied from time to time; there was the question of where police should be put, and many other matters upon which he need not dilate. Interesting suggestions had been made quite recently and were before Parliament at the present moment. Among those suggestions had been one of over-head roads, in regard to which he was pleased to state that Sir Alfred Yarrow, who had made a proposal and an offer to the London County Council, was present that evening and would show some slides of what he proposed as one solution of some of the difficulties of London traffic.

Probably Sir Lynden Macassey's views might have been slightly altered by recent events, but he was sure from the study which Sir Lynden had given to the subject, and from his intimate knowledge of many of its problems, the audience would listen with interest to an address which might throw some light upon the matter.

The paper read was :—

LONDON TRAFFIC.

By Sir Lynden Macassey, K.B.E., LL.D., D.Sc.,

Secretary to the Royal Commission on London Traffic, 1903-7.

When Lord Askwith asked me, as he did, some six months ago to read before the Royal Society of Arts a paper on London Traffic, the subject, important as it was then, had not become acutely controversial, and I accepted the invitation with pleasure: indeed, there was no escape. Lord Askwith, as you know, can mould a peremptory order into the ingratiating form of a request; it was that rare gift, added to his immense knowledge of industry, which made him our greatest industrial conciliator.

I had originally intended to read a paper dealing more or less critically with the political, municipal and technical questions connected with the various proposals that have been made from time to time for solving the London traffic problem. Indeed, I wrote such a paper some months ago, but in the last six days consigned it to the waste-paper basket. I felt it would not now serve any good purpose to read that type of paper because of the remarkable change in the whole situation that has occurred during the last two weeks. One of those phases of rapid transit, the strike of the tramway men and omnibus men, supervened like a bolt from the blue, and the problem ceased to be one that lent itself to critical discussion in public and became one for the judicial consideration of a Court of Inquiry. With the termination of the strike, and the conclusion of the Court's investigations, I found myself a few days ago reinvested with some liberty of speech, but that has been largely curtailed by the introduction yesterday into Parliament by the Government of the Bill relating to London Traffic, under circumstances which make me feel that I shall best assist the delicate and complicated negotiations that are involved, by laying my critical faculties for the moment under a stern self-denying ordinance. My address to-night must, therefore, take the form of somewhat general observations.

Public attention, by a turn of the wheel, has recently been directed to the congestion of traffic in London streets, very largely because of the British Empire Exhibition which is proposed to be opened shortly at Wembley. In view of the immi ence of the Exhibition, Londoners became apprehensive of the growing congestion of vehicular traffic in the streets, and began to realise the importance of providing freer movement for the great masses of traffic which the Exhibition will bring into the metropolis. History is always repeating itself. It was the Great Exhibition of 1851 in London which similarly forced on public attention the deplorable conditions which then existed in regard to the streets of the Metropolis. At that time, between the top of Northumberland Avenue and the Law Courts, there were no less than seven distinct Road Authorities, each repairing the Strand at different times, and taking good care that no one co-operated with any other. That fact in itself, and the approach of the Great Exhibition of 1851, led to an agitation which finally culminated in an inquiry, out of which came the recommendation for the constitution of the great Municipal Authority afterwards known as the Metropolitan Board of Works. We can date many of our road improvements in the last century from the Great Exhibition of 1851. Will the British Empire Exhibition of this year give a similar impulse to public opinion?

Labouring under the restrictions of the evening, I think I should probably be making best use of the wide publicity which properly attaches to any discussion in your distinguished Society if I were to focus in a convenient way before you what are the essential elements of the problem

of London traffic which confront the Government and the people of London at the present moment. May I, my Lord, with your permission, proceed along the following lines? I would like in the first place to emphasize the inherent difficulties of the situation; and I think I can do that most effectively by shortly summarising them as found by the Royal Commission on London Traffic, to which I had the honour of acting as Secretary. In the second place, I would like to refer to the broad principles underlying the remedies prescribed by that Commission, and I may say in passing, that few of those remedies have so far been applied in London. The London public has almost forgotten that such a Commission ever existed, although quite a substantial number of its recommendations have been adopted in foreign capitals. I found myself, after I ceased to be Secretary, involved in lengthy correspondence with the Municipal Authorities of several Continental Cities. Thirdly, I would like to indicate how far the London Traffic Bill of the Government, which has just been introduced into Parliament, follows out and harmonises with the recommendations of the Royal Commission.

The difficulties of the London Traffic problem, as diagnosed by the Royal Commission, were conveniently summarised by them under three main heads. The report of that Commission dealt first with the streets, and with all the various questions connected with street traffic. Secondly, it examined the public transport agencies operating either on the streets in the form of tramway cars or omnibuses, or below the streets in the form of tube railways. Thirdly, it discussed the railways serving the Metropolis, whether in the form of urban railways, such as the Metropolitan District Railway and the Metropolitan Railway, or in the nature of suburban sections of what for want of a better name I may call—although the great Railway Companies do not themselves like the sobriquet—the "main-line" railways.

There can be no question of the urgency of some remedial measures being immediately adopted. Dating as far back as the reign of Elizabeth documents are in existence in the archives of the Guildhall which use language very similar to what is being used to-day, to impress upon the attention of the Government the imperative necessity even at that time of freeing what they called, the "passage" through London streets. They show conclusively that much the same problem confronted the city fathers of those days as faces the Government or the great Municipal Authorities of London at present. As to the imperative necessity to-day for action, I do not think I could say to-night anything which would improve on what was written as far back as 1905 by the Royal Commission. This is a short passage from its report:—

"The magnitude of the population of London, and the extent of the area over which that population is spread, make the problem of locomotion specially important for London, and if the standard of movement cannot be raised to the level attained elsewhere, London must fall behind in competition with other cities, and the life and growth of the Metropolis will be slowly, but no less surely, strangled by the choking of the great arteries of traffic."

That was true in 1905, and more than true in 1924. The population of "Greater London" has increased substantially in the last 19 years, and the area which to-day constitutes "Traffic London" (because, after all, traffic laughs at municipal boundaries and parochial jealousies) has immensely widened since 1905. The distances which people travel to-day are much extended, and what may be called the "travel habit" has greatly grown and spread. Therefore, urgent as were the necessities at the time of the Royal Commission of dealing with London traffic, those necessities have since become enormously aggravated, until they represent at this moment one of the most serious and pressing social problems of metropolitan life.

The difficulties which have accumulated in regard to London's primary means of transit, namely, streets, are summarised succinctly by the Royal Commission, and I do not think I can do better than read something of what they said:—

"The chief difficulty that stands in the way of improving the means of locomotion in London is the narrowness of the streets, and the fact that they were not originally laid out on any general plan. If the streets were of sufficient width and had been laid out on a regular plan, the congestion of vehicular traffic would practically disappear; the long distance traffic could be provided for by shallow underground railways at a cost which

would not be prohibitive; and a complete system of surface tramways could be laid down, which would carry the short distance and miscellaneous passenger traffic of London cheaply and quickly."

I pause there to make this observation: at the time of the Royal Commission the wonderful possibilities of the motor-bus had not been appreciated. The Commission then went on to say:—

"The present unsatisfactory conditions are largely due to the fact that there did not exist in the past any Municipal or other Authority having jurisidiction over the whole area, and possessed of sufficient power and resources to enable it to deal satisfactorily with the problem of locomotion, and the other questions allied thereto. The history of the growth of London is, to a very great extent, a record of the aggregation of houses to the central, or original city, having an area of about one square mile. This central nucleus, still known as the City of London, was built, or grew up, at a time when the vast amount of business now transacted in it, and the volume of traffic that now flows through its streets, could not have been foreseen. Many street improvements have been made to relieve the special difficulties that forced themselves from time to time on the notice of the Authorities, but the great cost of such improvements, due to the high value of city property, stood in the way of any general reform, and the street accommodation of the City of London is inadequate to meet the requirements of the present day. As population increased, and business grew, various parishes and villages outside the City of London gradually became a portion of the metropolis, but were not assimilated by any central municipal authority. It is probable that the great extent to which, in early days, the river could be, and was, used as a means of communication from east to west prevented attention being given to the laying out of new streets and roads as London stretched out beyond its original limits. However that may be, the parishes preserved their separate and independent constitution and authority, and the state of confusion and administrative disorganisation that prevailed only fifty years ago is almost incredible."

The confusion and chaos flourished in profusion even when the Commission was reporting. I well remember investigating a number of cases around the metropolis where one Local Authority in the exercise of its powers under the local Building By-Laws, were actually putting pressure upon owners in their district to lay out new streets at right angles to the general lay-out of the streets in adjoining districts, so as to obstruct as far as possible the passage of through traffic, and thereby relieve the Authority, when it took over the streets, from the cost of street repairs due to traffic coming from districts beyond their own.

There are two other passages which I would also like to read:—

"It will be seen that London, only 50 years ago, consisted of a central area of about one square mile under the Corporation of the City of London, surrounded by parishes continually growing in population and in importance; each parish a law unto itself, uncontrolled by any central, municipal, or other local authority. Under such conditions grew up the Metropolis of the United Kingdom, composed of streets laid out without plan, tortuous in direction, varying in breadth, and generally insufficient in dimensions." . . "The wants of London, as a whole, in the matter of roads and streets, have never been sufficiently considered in the past. In the early days no municipal authority existed, outside the City of London, which could deal with the whole problem in a broad spirit, and London was allowed to grow up piece-meal as local conditions or accident prescribed. No sufficient provision was, or under such conditions could have been made to meet future requirements. The streets of the present day are frequently survivals of the village roads and lanes, developed into metropolitan thoroughfares under the care of small and independent local authorities, whose views did not extend beyond the requirements of the limited areas for which they were responsible."

So that, while we find that there were in existence in Paris, Berlin and Vienna plans which laid down the general lines, dimensions and directions, in accordance with which main streets and important thoroughfares were to be developed, nothing of the kind at any time existed in London. Never any co-ordination—nothing but

parochial jealousies; nothing but bumbledom *in excelsis*, each parish forming its new roads on its own petty plan, or turning what were originally cow-tracks into main thoroughfares.

Such was the evolution of London streets. As regards the means of transit on the streets, I can epitomise the Commission's conclusions; they are equally true to-day.

"Insufficiency of mileage is not the only defect of the tramway service in London. Within the County of London nearly the whole of the tramways are owned, and in great part are worked, by the London County Council, whose policy has been consistently directed to the exclusion of private promoters from within the County of London; such tramways within their jurisdiction as do not already belong to them will be acquired, under existing powers, in the course of a few years.

"In the districts of 'Greater London,' lying outside the administrative County of London, a different policy in general prevails: the tramways are largely worked by private companies. This difference of policy would not necessarily entail inconvenience if the systems on the outside were worked in harmony with those inside, so that cars should run continuously across the frontier. Unfortunately, that is not the case. The systems where they meet at the frontier are not always physically connected, and, in no case is there through running. Accordingly every through passenger is obliged to change cars.

"Inside the Administrative County of London itself there are also very serious defects. Three systems of tramways are included in this area: the northern and eastern system, wholly north of the Thames; and the southern system, wholly south of the Thames. All these three systems are separated from each other by long intervals, without any connection, as will be seen by a reference to the Tramway Plan; while great districts in the centre of London, including the city, the West End, and the chief places of public resort, are entirely unprovided with tramway service. The different lines approach those districts and then break off abruptly in the middle of the street.

"As a result, all the cars are obliged to discharge their passengers at dead-end terminals. At the six principal terminals (Westminster Bridge, Shepherd's Bush, Blackfriars Bridge, Aldgate, Newgate and Euston Road) nearly a quarter of a million of passengers alight from, or join, the cars every day in the streets; apart from the great inconvenience caused to all or most of the passengers, the result is a great congestion, both of tramcars and of ordinary vehicular and pedestrian traffic, at these terminal points; and the same congestion, though in a less degree, occurs at the other terminals in London.

"It will be seen that, from every point of view, tramway accommodation is glaringly defective. In a great area there is no tramway service at all. Where there is such a service, travellers do not obtain the full advantage which it ought to provide, in cheapness, expedition and convenience. An 'end-on' break in the course of a journey probably causes additional expense (for two independent fares usually cost more than a through fare), whilst the consequent delay and discomfort, especially in bad weather, and the uncertainty of transshipment, are great drawbacks. Where the line abruptly terminates in the middle of crowded streets, even greater discomfort is caused, together with serious diminution of efficiency in the entire tramway service, and an intolerable congestion in the streets."

"It is difficult to appreciate how such a state of things can have been tolerated so long. Whatever view may be held upon the expediency of extending tramways in London, it cannot be expedient to work those we have upon inefficient methods."

This was written in 1905. With the exceptions that at Westminster Bridge and Blackfriars "dead-end" terminals have now been abolished as a result of the extension of the London County Council tramways over Blackfriars and Westminster Bridges and along the Thames Embankment, and that through tickets are issued over the tramway, omnibus and tube-railway systems of the Underground Company, these observations of the Royal Commission are as appropriate to-day as they were when they were written.

So far as omnibuses were concerned, the Commission drew attention to the fact that

their services were wholly uncontrolled, and complained of the public disadvantages that would ensue if the position were not remedied. The Commission's advice was wholly disregarded, and the trouble has now supervened in an acute and controversial form. The Commission commented adversely upon the fact that it was possible for any person who obtained a licence from the Metropolitan Police (who were the Licensing Authority for the Metropolitan Police District) and from the City of London Licensing Authority to put an omnibus on any route in Greater London he thought fit, without being subject to any control whatsoever in regard to route, comprehensiveness of service, time-table, fares, etc., thereby differing entirely from the practice in Paris, Berlin or Vienna, where the right of any person to put an omnibus on particular public streets is derived from a "concession," which imposes, in the interests of the public, certain definite obligations on the concessionaire.

In regard to railways this was and is still the position. Their construction has been entirely a question of haphazard growth. There was never any plan providing for the general lines of their development, as existed in Paris, as exists to-day in Berlin, and as did exist in Vienna. The only questions touching London railways that actively agitated the mind of Parliament or of municipalities in mid-Victorian days were three, namely, whether there should or should not be a great central station in London which would form the general terminus of all main-line railways; whether there should or should not be an "outer circle railway" connecting the main-lines somewhere outside the central districts of London and providing facilities for the exchange of goods traffic so as to avoid the necessity of passing goods waggons over crowded city lines or the cartage of goods through the congested streets of the Metropolis; and whether there should or should not be an "inner circle area" in London into which no main-line railway should be entitled to penetrate, but round which an underground railway should be built to connect up the main-line termini. The central station project was ultimately rejected; there were several fruitless schemes to construct an "outer circle railway," but the inner circle proposal was ultimately carried out.

Such were the outstanding features of the London Traffic problem. I will now endeavour, without going into any great detail, to indicate the general lines which the Royal Commission's recommendations for the improvement of the situation followed. It is desirable to bear in mind that that Commission obtained the best possible technical assistance from eminent persons of the greatest experience, in close touch with the practical realities of the problem. They were also advised by Sir John Wolfe Barry and Sir Benjamin Baker, both well-known and distinguished engineers in London, and by Mr. William Barcley Parsons, who was the Rapid Transit Engineer to the City of New York.

The guiding principle the Commission formulated—and it is, I venture to think, to-day a principle which calls more urgently for application than ever it did—was that there should be co-ordination of all means of transit. They pointed out that you cannot deal with the problem of London traffic in watertight compartments—that it is one problem undivided and indivisible. You cannot treat it as a series of separate problems whereby particular sections of London are to be served by railway or tramway or motor-bus. They emphasised the obvious and indisputable fact that no proper solution of the problem can be devised unless "Traffic London," whatever be its municipal boundaries, is treated as a whole, and unless all the means of transit serving "Traffic London" are worked in the closest co-ordination and co-operation. At that time—and even to an accentuated extent to-day—the artificial barriers which severed one transit system and another were largely the result not of traffic causes, but of parochial jealousies. Certain municipalities owned their tramways, and, of course, objected to anything in the nature of private enterprise operating in their district. In other local districts private enterprise afforded the facilities, and was denied a chance of working in co-operation with adjoining municipal systems. Therefore, the Commission laid stress on this fundamental point, that anything in the nature of a real, true, comprehensive co-ordination of the means of transit in "Traffic London" involved the repudiation by Parliament or whatever other competent authority existed, of those petty, futile and injurious distinctions as between municipal enterprise and private enterprise in matters of transit, founded

not on any considerations of economy and efficiency of service, but on partisanship and prejudice.

I need not say that the area which the Commission recommended should be treated as "Traffic London" was the area known as "Greater London." Since that time, owing to the extension of London and the increasing distances people travel, an even wider traffic area than that of "Greater London" was contemplated by the recent Royal Commission on London Government.

In order to secure co-ordination the Commission laid down as the first cardinal principle, that there should, as far as possible, be amalgamation of the various systems of transit. In other words, the bigger the system, the better and the more comprehensive and the cheaper are the facilities that can be afforded to the public on an economic basis. But at that time every possible difficulty was being presented to amalgamation. In that respect this country differs extraordinarily from other countries, notably the United States of America, where every possible facility is given for the consolidation of transport undertakings, or even in countries where State enterprise is more or less the rule, as, for example in France and Germany. With the experience of all those countries to guide it, the Commission strongly urged that all possible freedom should be given to company undertakings to amalgamate. Notwithstanding that authoritative pronouncement, since that date every possible impediment has been imposed by Parliament and the Local Authorities in the way of company undertakings in the metropolitan area consolidating their respective systems. One has only to recall the history of the tube railways which exist to-day in London. They were originally authorised as local independent schemes from one point to another in the hands of separate companies, and they were only amalgamated into the present system of the London Electric Railway Company under the very greatest difficulties, and in the face of formidable opposition in Parliament. The Commission also were strongly of opinion that obstacles should not be placed in the way of amalgamation of a statutory company, *i.e.*, one incorporated by special Act of Parliament, and a limited liability company incorporated under the Companies Consolidation Act, 1908. The present position of transport companies is most illogical. Railway companies generally must be constituted by and obtain their powers from special Acts of Parliament; Tramway companies are companies incorporated sometimes by Act of Parliament and sometimes under the Joint Stock Companies' Acts, but in each case operating a system of tramways authorised by a special Act of Parliament or by a Provisional Order confirmed by an Act of Parliament. A light railway company is usually constituted by a Departmental Order, made under the authority of the Light Railways Act, to construct and work the light railway authorised by the Order. An omnibus company is incorporated under the Joint Stock Companies' Acts to work buses wherever it can get a licence. The Commission accordingly recommended that every facility should be afforded for the consolidation of transport undertakings and the working of those undertakings as one undertaking even if the owners were statutory companies or joint stock companies, or companies incorporated by Departmental Order. For some reason which it is not easy to ascertain Parliament has not given, and is not disposed to give, any facilities whatsoever for the amalgamation of these different kinds of transport companies. As a result various kinds of expedients have to be used to try and secure for the travelling public some of the advantages of consolidation, but they can hardly be viewed as entirely satisfactory. One can refer to the well-known arrangement sanctioned by a special Act of Parliament under which the five separate Underground Companies:—The Metropolitan District Railway Company; the London Electric Railway Company; the City and South London Company; the Central London Railway Company and the London General Omnibus Company—maintain a common pool. Into it they pay their net receipts after payment of working expenses and interest charges, and then the total amount of net receipts in the pool is distributed among the contributing companies by mutual agreement. The result of this complicated arrangement is that a basis is provided on which those five respective undertakings can be worked as a whole, and facilities afforded in some direction by one company which perhaps the individual means of that particular company would not justify it as a separate entity in providing. The pool supplies means for affording those facilities by placing the financial

risk on the combined resources of the five co-operating undertakings. It seems inexplicable that it should be necessary for companies to resort to a makeshift contrivance of that sort as a means of effecting what ought to be effected and ought to be permitted through amalgamation of the companies' respective undertakings. The Railways Act of 1921 has provided for the amalgamation of many railway companies into four large railway groups. Why the advantages of amalgamation, which has been accepted by Parliament as the proper principle for the great main-line railway companies, should be denied to local metropolitan transport undertakings, passes ordinary comprehension.

Involved in the principle of co-ordination, which was so strongly advocated by the Royal Commission, was restriction of competition, so far as local railways, tramways and omnibus services in Greater London were concerned. This recommendation was considerably before its time, and it was many years before the public were prepared to endorse the wisdom of the view, but experience since that time has absolutely confirmed its soundness, and Parliament, in the Railway Act of 1921, has adopted and applied it to the main-line railway companies. The days are indeed past when it can be suggested that unrestricted competition affords a permanent and satisfactory basis for providing the travelling public in one large district with the most efficient and comprehensive and cheapest means of transit.

Following along and applying this general principle of co-ordination, which is the foundation of the Royal Commission's report, the Commission recommended that where amalgamations of transport undertakings for any reason could not be effected, unified working should everywhere be made possible, and indeed insisted, and were sufficiently courageous to say that if the working in any particular district of several undertakings as one meant the leasing of municipal tramways to a company to work, or meant a Municipal Corporation working all or any part of a company's tramways in its district, such arrangements should be adopted in order to ensure unified operation without any regard to prejudices or susceptibilities, if that seemed to be the effective way of providing the travelling public with the facilities of transit which they needed. But even to-day any proposition of that sort would meet with considerable political, municipal and other opposition, however outstanding were its economic advantages.

Again, proceeding resolutely towards the goal of co-ordination to which all its recommendations converged, in cases where unified working was not a practicable proposition, the Commission recommended traffic agreements providing for joint or through working, or territorial limitation or extension of operations, so as to ensure comprehensive and efficient services, and in order to eliminate overlapping and wasteful competition. Such agreements may take in practice many different forms, and involve the pooling of receipts, the division of the through fares and self-abnegation in various forms. I can appeal to the experience of those present this evening to corroborate how little of this is going on in London to-day, and what opposition is raised on all sorts of trivial grounds to every such proposal. Yet it is really of the essence of providing comprehensive and co-ordinated services that these barrier lines which exist between municipal enterprise and private enterprise should be broken down, and that apart altogether from political or other considerations, arrangements should be made for the working in harmonious unison of municipal systems of transit and companies' systems in the common interest of the travelling public.

If co-ordination was ever to be achieved, the Commission pointed out that there must be effective control over the construction and working of all systems of transport. At the time there were many objections to such a proposal. The Company said, "Why should any authority exercise control over us if they do not share in the financial responsibility of the undertaking?" The Municipality said: "No interference in our house; our local government electors should be supreme in their own district." Both forget that there was and is a considerable amount of control already existing over fares and services. If, for example, we take the question of fares, on all railways to which the Railways Act, 1921, applies fares will be subject after "the appointed day" to the jurisdiction of the Railway Rates Tribunal. On tramways the fares are fixed by special Act of Parliament or by a Provisional Order confirmed by Act of Parliament. In regard to omnibuses

there is no control whatsoever as to fares. As to services and facilities, so far as railways are concerned, there is a certain amount of control exercised by the Railway Rates Tribunal or the Railway and Canal Commission. Over tramways some control is exercised by the Ministry of Transport in regard to services for workmen. The point of principle, therefore, on which the Royal Commission insisted, that there should be some fair and comprehensive and effective control over the co-ordination of, and the services and fares on all public transport systems in London, has already in great measure been accepted by the Legislature, but its partial application frustrates the benefit that would otherwise have arisen from it.

The Commission next emphasised how urgently necessary it was that the provision of all transit facilities should proceed on the lines of a "general plan," which had regard not to the circumstances of a particular district, but to the needs of "Traffic London." It pointed out, in justification of this important proposal, the haphazard growth in London of roads and of streets, of railways and of tramways, and of omnibus routes; it referred to the very different evolution of transit services in Paris, Berlin and Vienna, where transport systems were developed on the lines of a general plan. It enumerated the numerous public advantages that would result if a general plan for "Traffic London" were prepared and kept up to date by a competent authority providing for the co-ordination and future development of transit services.

In order to provide and maintain this vital element of control the Commission urged the appointment of a Traffic Board. The most effective and efficient Traffic Board would probably be some competent dictator, but that in our democratic country is a Utopian conception. It, therefore, recommended the appointment of three persons to whom numerous and responsible duties would be confided. That was the particular rock on which the Report of the Royal Commission was ultimately wrecked. The proposal immediately gave birth to a widespread agitation. Municipalities in London and in the neighbourhood expressed their firm determination under no circumstances to come under the control of anything in the nature of a Traffic Board; they insisted on their full and unfettered right to remain dictators in their own areas. A prolonged political controversy ensued, the effect of which was to stifle, for many years, any prospect of carrying into practical effect the report of the Royal Commission.

The London Traffic Bill which has been recently introduced into Parliament is a notable advance in the direction, so forcibly outlined by the Commission, as alone affording any hope of alleviation, let alone solution of the London Traffic Problem. It proposes in the first instance to constitute an Advisory Committee, consisting of a Chairman, appointed by the Ministry of Transport, 12 ordinary members and six additional members. Personally, I should have liked to have seen a small, compact, expert Traffic Board responsible to Parliament through the Ministerial Head of some Government Department, but if, from the political and municipal temper of the times, that is unattainable, then I welcome the proposal of the Government to appoint an Advisory Committee, constituted as proposed by the Bill, as a substantial approach to the ideal of the Royal Commission. The 12 ordinary members of the Committee represent the Public Departments, the Ministry of Transport, the local and highway authorities of the area which is to be treated as "Traffic London," and which is considerably larger than "Greater London." Two of the additional members are to represent the interests of labour engaged in the public transport services in Traffic London, and the remaining four will represent what I may call the Companies owning or operating those services. The main criticism of a representative committee of this kind, to deal with acutely controversial questions, is that there is a great danger of their effective decisions being shorn of all decisive action in order to secure compromise, and of this procedure degenerating into something resembling harmonious static equilibrium. I would have liked to have seen a small body imbued with plenty of dynamic force, invested with, and under no compulsion to refrain from exercising, powers of initiative, and with functions not confined merely to advising on such particular matters only as are referred to them by the Minister of Transport; but I recognise that in regard to the London Traffic Problem, the present-day principle must be "*Solvitur Ambulando.*" An immense amount of education must be effected amongst the Municipalities and all others connected with the provision of transport in London, and an attitude of mind and

outlook cultivated to look on the other side of the question than that which immediately concerns themselves. All concerned in London traffic—and what citizen of London is not?—ought to welcome this Bill as being, if nothing more, at least the cradle out of which a really effective traffic authority for the Metropolis may ultimately be reared. If the right Chairman be appointed,—for with such a nicely balanced Committee, everything will depend on him,—the Committee proposed by the Bill will be able to do work of incalculable public benefit. Its very existence, and the opportunities it will provide for friendly discussion between the representatives of what have been hitherto almost hostile interests, will tend to extinguish many of the prejudices and assuage many of the asperities that have for so long militated against the provision of real co-ordination of the various traffic services in the Metropolis. In course of time I have every hope that a true spirit of co-operation will be engendered. I do not know how widely the Minister of Transport intends that the functions of the Committee are to extend—whether they are to embrace roads and streets, railways and tubes, tramways and omnibuses, or whether some more limited scope is contemplated; but I trust that their scope will be as comprehensive as is possible.

The next important provision of the Bill deals with the question of the street obstructions caused by the execution of street repair work, and by the breaking up of streets to lay pipes, cables and wires. Any of us who use the streets of London, or who lighten the burden of life by enjoying the humour of "Punch," know what an unnecessary and perfectly ridiculous amount of obstruction is caused by the inveterate and insatiable passion of every authority with statutory powers over the thoroughfares of the metropolis, to break them up at different times, without any sort of co-ordination, and make them almost impassable for traffic. The Bill represents a praiseworthy attempt to compel all such authorities to arrange a normal seasonal programme for any work involving interference with the surfaces of streets, so that, except in case of emergency, all such work may be done at one and the same time —a reform insisted on by the Royal Commission and regrettably overdue.

The next important clause in the Bill is the power which it is proposed to confer upon the Omnibus Licensing Authorities in "Greater London," that is to say, the City Police in the City of London, the Metropolitan Police in the County of London, to attach conditions to omnibus licences. That is absolutely essential if an efficient, comprehensive omnibus service is to be secured. There can be no reason whatsoever why we in London should be in a worse position than other cities abroad. It cuts at the very root of providing a comprehensive and efficient omnibus service if it be possible for any person who obtains an omnibus licence to put his omnibus on any route he thinks fit for just as long, or for such periods of the day as he chooses, and thereby skim the cream off the traffic of those routes and evade what ought to be the responsibility of any public transit undertaker, namely, to provide traffic facilities, not merely on a route at profitable times, but at all times, and not merely on the most profitable routes, but on routes which are not so profitable. In traffic operation good routes must pay for bad routes; by no other means can comprehensive facilities be provided.

It can hardly be suggested that the proposal in the Bill constitutes any very onerous restriction on the liberty of omnibus licensees. Indeed, when one considers what the public interests demand, and what is the existing practice in foreign capitals, it may be argued, and not at all unfairly, that the provisions of the Bill will preserve for the metropolitan omnibus licensee a latitude of choice in regard to when and where and how he will operate his licensed omnibuses very considerably greater than that to which he might reasonably be restricted in the interests of the welfare of the travelling public of "Greater London."

As complementary to the powers of the Omnibus Licensing Authorities in "Greater London" to attach conditions to omnibus licences providing for a proper service, the Minister of Transport himself takes power under another clause in the Bill to limit, either generally or during particular hours, and subject to certain safeguards, the number of omnibuses plying for hire in any street or part of a street within "Greater London," when he is of opinion that by reason of the width of the street, or the existence of alternative facilities for the conveyance of passengers along the street, or in its vicinity, the number of omnibuses

plying for hire along the street is excessive, and the Minister may determine the omnibus proprietors who shall solely or jointly be permitted to operate their omnibuses through any such street. A power such as this was thought necessary by the Royal Commission as far back as 1905. How much more is it necessary to-day to deal with the swelling flood on London streets of heterogeneous and unnecessary omnibuses, which are being pressed into operation, not to provide a permanent and reliable service for the benefit of the public, but to snatch a transient profit at the cost of tramways and tube railways, which, unlike the mobile omnibus, are anchored fast to definite routes, and cannot be diverted from route to route as fancy dictates or profits attract. All such unnecessary omnibuses are a public detriment and not a public benefit. The public is no better served. They are merely carried on an omnibus and not on a tube railway. In the end the public must inevitably suffer. Tube railways and tramways must of a certainty reduce the facilities they offer to the travelling public if revenue which is legitimately theirs, and for which so large a permanent investment has been hazarded, is to be diverted from their already slenderly filled coffers into the pockets of irresponsible omnibus proprietors. One important comment does arise upon this clause of the Bill. It seems unfortunate that the Minister of Transport is taking no power under the clause to regulate services upon metropolitan tramways, whether owned by companies or by local authorities.

In addition the Bill confers upon the Minister of Transport on lines recommended by the Royal Commission power to make a large number of regulations, in regard to preventing obstructions in the streets and facilitating passage through them, subject to disallowance by Order in Council on an address being presented to the King, praying for such disallowance by either House of Parliament. The various matters in respect of which such regulations may be made are too numerous to mention; they are set out very fully in the Third Schedule to the Bill.

I may, in conclusion, sum up the effect of the Bill now presented to Parliament, by saying that it marks an earnest attempt on the part of the Government to go a considerable way towards carrying into effect the recommendations of the Royal Commission on London Traffic, although there are, as has been pointed out, very important and very serious omissions. There is one particular deficiency. The Bill contains no provisions enabling transit authorities, whether Company or Municipal, to enter into agreements providing for the co-ordination of their respective systems under any arrangement which seems mutually satisfactory, and involving it may be pooling of traffic revenues and their distribution as agreed. There should be no objection to giving effect to this all-important recommendation of the Royal Commission. Such a power should be conferred upon the owners of transit systems in London, be they municipalities or be they companies. No political or municipal prejudice should be allowed to weigh against the crying needs of London's travelling public.

This is a subject on which, no doubt, a number of distinguished gentlemen whom I see present, and who are closely connected with the London Traffic Problem, may possibly desire to speak, and, therefore, I shall not occupy the time of the meeting further, except to say this. Speaking under the limitations of the moment, my object in this address was a limited one, namely, to indicate what were the fundamental difficulties of the problem; secondly, to show in broad outline and in some attempt at balanced perspective the main lines along which the Royal Commission, after four years of close investigation in this country, on the Continent of Europe, and in the United States of America, assisted by the most expert and experienced traffic and technical advisers of the day, were of opinion that the solution of the problem lay, and, thirdly, to indicate how far the present London Traffic Bill of the Government carries into practical effect the recommendations of the Commission.

My Lord, ladies and gentlemen, I thank you most profoundly for your kind and sustained attention, and I venture to hope that what I have said may afford some basis for a profitable and interesting discussion.

DISCUSSION.

SIR ALFRED YARROW, Bt., M.Inst.C.E., F.R.S., in opening the discussion, thanked Sir Lynden Macassey for having placed before the audience in a very clear way one of the most difficult problems of the day.

The congestion of the traffic in London had

greatly interested him of late, because he had been one of hundreds of thousands of people who were anxious to hurry on, and who had been kept waiting owing to the congestion that occurred,

(1) Partly through one line of traffic crossing another on the same level,

(2) Partly through the traffic being stopped to allow pedestrians to cross the road, and

(3) Partly on account of horse vehicles, which could not keep up the speed of the present day.

If the value of the time people lost owing to such stoppages could be estimated, it would work out to a colossal sum,—many millions sterling per annum; and, having in view the loss to the nation through such waste of time, money might well be spent in organising various methods of alleviating the present congestion.

With regard to horse traffic, two years ago he had been in Seattle, one of the most rising cities on the Pacific coast. He had been struck by the fact that horses appeared to be extinct. He had taken a drive for three hours to see the city, and during that time he had only seen one horse, and it was lame! That was an example which foreshadowed what would probably happen in in this country in the distant future, and, therefore, any arrangement made should have this change from horse to motor kept in view.

As regarded facilitating pedestrians crossing the roads, in Seattle they had an excellent system. At certain intervals there were two white lines, about 15 feet apart, painted across the road. From one pair of lines to the next pair the traffic was allowed unlimited speed. (In Seattle motorists were not fined for going too fast, as here, but for going too slow!). When a car approached the white lines the chauffeur had to slow down to three or four miles an hour and just crawl across the space allotted for pedestrians to cross. If anyone wished to cross the road in safety he must do so at such places, as between the lines all cars went very slowly and could therefore stop instantly in case of necessity. If pedestrians crossed at any other places they did so at their own risk. That scheme worked exceedingly well, and he saw no reason why something of the same kind should not be adopted in this country. It would avoid the police stopping the traffic for people to cross. If such crossing places were adopted say in Regent Street there would be six or eight between Oxford Street and Piccadilly Circus.

So much for the horses and for people crossing the roads.

Coming to the most important difficulty of all, namely, where two lines of traffic crossed on the same level, it did not require the wisdom of Solomon to see that when one line of traffic was passing the other must stop. The only way to prevent that was for the lines of traffic to cross on different levels. That had been proposed over and over again, and was carried out in railway practice. The one line of traffic could pass through a tunnel, or it might pass over the other, which ever might be most advantageous under the special

FIG. 1.—Photograph of Model illustrating High Level Crossing so that the Traffic in one direction does not interfere with the Traffic passing at right angles.

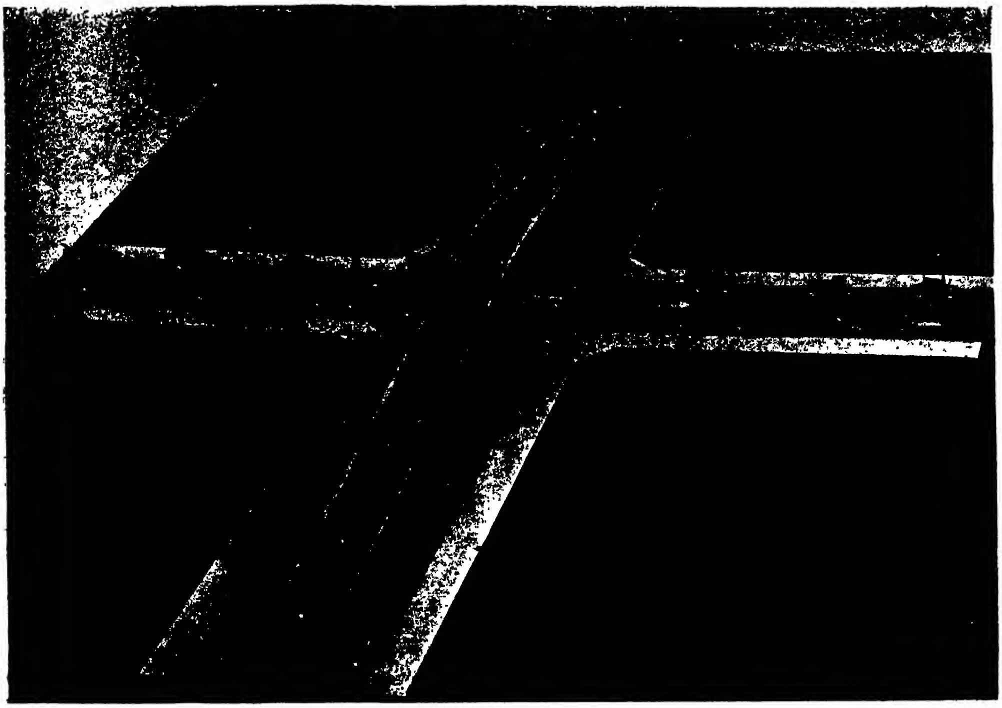

FIG. 2.—Photograph of Model illustrating a High Level Crossing so that the traffic in one direction does not interfere with the traffic passing at right angles.

circumstances of each case. In the London streets it was difficult to burrow underground on account of sewers, water-pipes, gas-pipes, electric mains, underground railways, etc., and, therefore, in most cases, it only remained for the crossing to be effected by means of an elevated road.

He had had some models made (Figs. 1 and 2), slides of which would be thrown on the screen, showing how that plan could be carried out. With regard to the height above the roadway which was crossed, 16′ 6″ would be sufficient to allow for a 6ft. man to stand on the top of an omnibus and leave 12 inches clearance.

With regard to the width of roadway for the high-level crossing, if 18 feet could be obtained for two lines of traffic (one going in one direction, and one in the other) it would be desirable (see Fig. 3); but 16ft. would be sufficient, and that was found ample in actual practice in the Blackwall Tunnel.

It might be necessary to have a kerb to keep each line of traffic distinct from one another, so as to avoid any possibility of collision.

On each side of the elevated road there should be room for a car to stand by the side of the pavement, and also one to pass; but as they would not be passing in opposite directions he ventured to think that 16ft. certainly would be ample. He believed he was right in saying that 15′ 6″ was considered sufficient by the Glasgow Authorities.

With regard to the incline, he thought that one in thirteen was suitable. He lived near Guildford. Guildford High Street had a rise of one in ten, and that was ascended by all kinds of vehicles, and he had never heard anybody complain that it was too steep. Therefore, if an incline less than

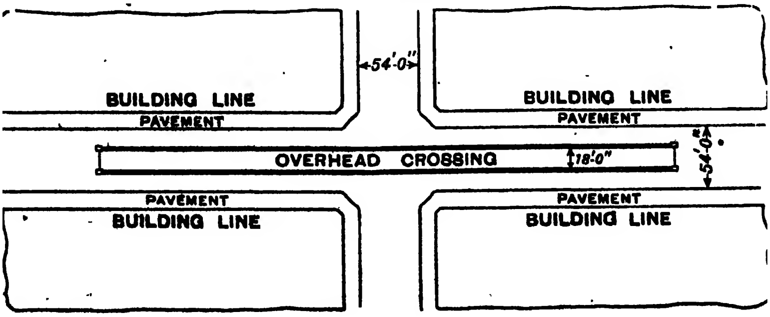

FIG. 3.

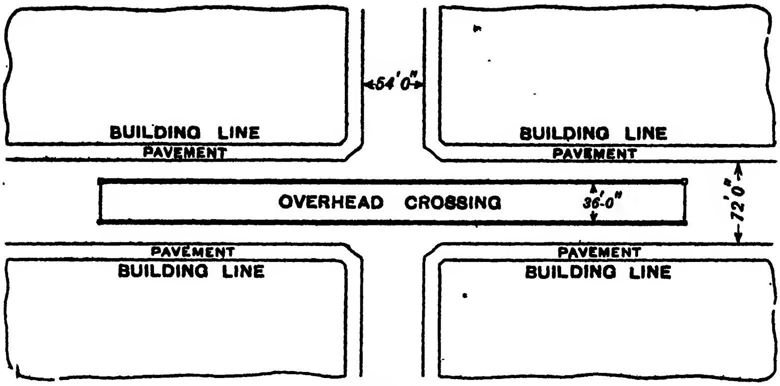

FIG. 4.

Guildford was adopted, that should meet all necessary requirements.

There was one point in connection with a high level crossing which was a decided advantage to the property owners on each side, and that was, motors could be parked in safety under the approaches and were thus easily available, instead of, as at present, having to be sent up a side street where one often did not know where the car was to be found. Therefore he ventured to think that any contention that a high level crossing was a drawback to the shops was more than counteracted by the facility for parking the cars.

Under the present circumstances he was afraid the width of the streets would never admit of more width for the overhead road than sufficient for two lines of vehicles going in opposite directions; but in any new roads that were made it would be wise to have the overhead road wide enough to take four lines of traffic. (See Fig. 4).

The various views which would be thrown on the screen showed different views of the model, and he thought they would speak for themselves. Fig. 3 showed the width desirable in order to carry out the scheme, with one line of traffic in each direction. over the high level crossing. Fig. 4 showed a sufficient width of overhead roadway to admit of four lines of traffic along the high level crossing, two in each direction. He suggested that for new roads, where there was likely to be congestion due to two lines of traffic crossing on the same level, the wider overhead road would be desirable, involving a total width between curbs of 72 feet. If the width of the road between the curbs was 40 feet, then the width of the passage at the sides of the high level crossing would only admit of one line of vehicles, and the police should have authority to insist that no motors should remain standing. If 48 feet width of road between the curbs were available then on one side of the high level crossing there would be room for two vehicles to pass, and on the other side there would be room for only one line of motors, and on this side the building line might be set back at some future time. With reference to appearance, the scheme gave a fine opportunity for the architect to show his artistic skill in designing something that would correspond to the surroundings, and Fig. 5 showed what such a structure might be like.

If arrangements were made for people to cross the road as was done in Seattle with success; if horses were forbidden to go along the main thoroughfares; and if there were overhead roads such as he had indicated, the traffic difficulty would possibly be met.

Of course, in dealing with this subject it must be borne in mind that whatever number of cars there were on the roads now, in ten years' time there would probably be double the number, which corresponded to the increase which had taken place during the last five years.

He would point out that it was reasonable, as the road traffic was increasing much more rapidly than the foot traffic, that a slice might be taken off the pavement in cases where the building line was set back, and not for all the increased space to be given to the foot passengers.

He might mention, in conclusion, that he had no financial interest whatever in any scheme. What he was doing was on public grounds, because the present condition was intolerable and it would get worse and worse every day.

SIR GEORGE HUME (Ex-Chairman, L.C.C. Highways Committee) said that he had some trepidation in speaking on this subject, because unfortunately the London County Council seemed to carry with it an atmosphere of controversy which did not tend to the useful solution of the problems with which the Society was dealing that evening. It was interesting to have the opportunity of hearing Sir Lynden Macassey who was so closely connected with this problem at a time when there was not so much fever in the illness as there was to-day. It was good to hear him lay down once more the principles which the Royal Commission had set out so clearly and apply them to the Bill which at the present moment was before the House of Commons. There had been a good many happenings since the days of the Royal Commission. There had been enquiry after enquiry. The House of Commons had considered the matter through special Committees. There had been a Committee

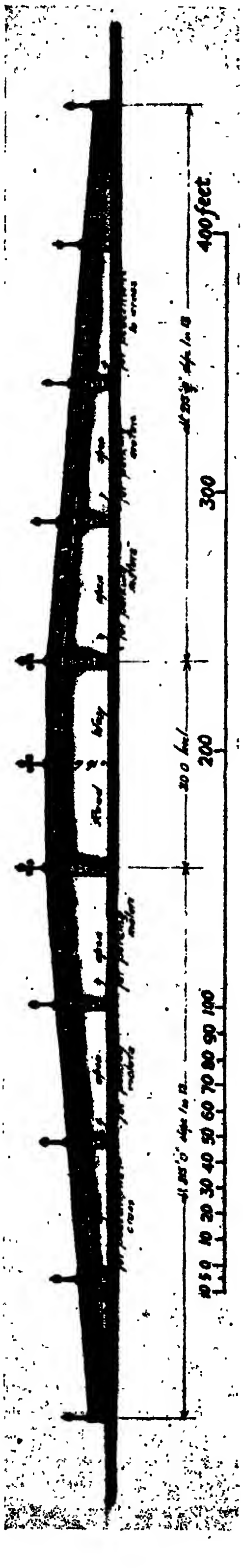

FIG. 5.—Elevation of Proposed High Level Crossing.

sitting at the Ministry of Transport under Mr. Kennedy Jones, of which the speaker was a member, and on which an attempt was made to see how this problem could be dealt with in such a way as to obtain legislative sanction. So far as the London County Council was concerned it had been wide-awake to this problem for many long years. By resolution, ever since the Royal Commission sat, the County Council had been pressing for the setting up of a Traffic Board, but successive Governments had had more interesting matters to deal with and London had gone on its way. Recently, no doubt, owing to the intervention of a number of buses which did not happen to be in what was known as the "combine," they were finding the streets rapidly filling up with traffic which had undoubtedly very much emphasised the difficulty from which they were suffering. The recent strike in the London traffic industry had added a picturesque touch to the problem. London had been denied its trams and omnibuses for something like ten days. The solution of that difficulty and the return of the men to work was, he believed, largely facilitated by the undertaking which the Government gave that they would bring in the Traffic Bill which they found in the pigeon holes when they took office. This Bill was to have been brought forward last year, and it had come before them with just a few touches to give it a little local colour. There were those who said that this was a problem which ought to be handled by the Municipal Authorities. On the London County Council they took that same view, but they took it as an ideal. They did not like the interference of any Government Departments. But it had been impossible to set up any Municipal Authority. Suggestion after suggestion was made and finally, in a very rash moment, the suggestion was made that London government generally should be remodelled. The Royal Commission sat on it, but the result was that in another sense it did sit on it! The problem was still with them. It was a burning problem, and the line they took at the London County Council was that in view of all the jealousy between authorities, no matter who brought forward the proposal, they for once should do something original, and although they did not like the Bill now before Parliament they were not going to oppose it. It was the only practicable thing they could hope for at present. If this Bill was scrapped there was nothing to replace it, and they would have to go blundering on from year to year without finding a solution for this problem. On those grounds the London County Council decided not to oppose the Bill, but hoped to make certain amendments in Committee, because happily at the moment a Government was in power which did not mind having its own measures cut about. Sir Lynden Macassey had touched on the question of co-ordination, a very interesting subject. That very troublesome body, the London County Council, had even awakened to that aspect of the situation. It did not allow itself to be absolutely paralysed by the contemplation of the iniquities of the "combine," and as good citizens, seeing that

the State would do nothing for them, they did get together and make a most serious attempt to see if something could be done for themselves. In order that it should not be suggested that the London County Council was attempting to give away London's birthright to private enterprise, they succeeded in capturing the Minister of Transport, whose representative presided over the discussions, and so gave a guarantee that everything was fair and square. He ventured to say that it was not the fault of the "combine" or the London County Council if this problem had not been dealt with. All three parties on the Council came into these negotiations, but before they came to the end of their labours one party dropped out while another refused to accept the final conclusions. He did not wish to take up more of the time of the Society, because this was a subject on which a great deal might be said. It was something to have succeeded in getting a certain number of men representing different interests around one table to talk over this problem with an earnest desire to solve it. In that respect some good work would be done by this new body during the first three years of its existence, and then it might go out of existence and something else take its place. But it was very urgent that something should be done.

Colonel C. H. Bressey (Ministry of Transport), said at that late hour it was very difficult for anyone to speak adequately of London traffic, and as he was a representative of the Ministry it was as well that his words should be as few as possible. Obviously any discussion regarding policy on his part would be out of place. He had had the honour of working with Sir George Hume in connection with many problems relating to London traffic, and he knew what a weighty part he had played in these discussions. As an expert he ranked second only to Sir Lynden Macassey, the author of the great text book and encyclopædia on London traffic. There was no doubt at all as to the wide area which the London Traffic Authority would have to control. One could see to-day the most unexpected developments taking place. Any Traffic Authority set up must have an area extending as far as possible into those districts outside London whose development was still open to control and could be usefully controlled in the public interest. For example, take the air service: the aerodromes were as far afield as Waddon and Hendon. The air service was not meant particularly to serve the places at which the aerodromes were located, but it was meant to serve London, and the interests of London traffic in this particular might be supposed to extend to those places. That was a hint as to how far afield London's traffic interests might stretch. Sir Lynden Macassey had made a reference to the extraordinary parcellation of London, its minute sub-division, and in this respect he would like to mention a fact recently published in *The Observer* referring to the state of Lambeth 100 years ago, when in an area of one square mile 16 toll gates were set up for the restriction of traffic. Many of the authorities of that day and perhaps later were more concerned in restricting traffic than in promoting its movements. In the East End one saw the side streets which had been narrowed down in order that, in the turnpike era, the traffic should be driven off those narrow streets which produced no revenue into the turnpike road which did. As Sir George Hume had said the great point was not to search for impossible ideals, although these might come later, but to seize some practicable solution which would stand a chance of acceptance, perhaps with some reluctance, by all concerned. In 1855 the Metropolitan Board of Works was set up. That was succeeded in due time by the London County Council, with far greater powers, which had worked with far more credit to the Metropolis. Something of the same evolution might take place with regard to traffic, and it was the desire of them all to see the developments in traffic controlled to the best interests of all the citizens of London.

Mr. Frank Pick (Assistant Managing Director, Underground Railways) said that he had listened with much interest to Sir Lynden Macassey, and he agreed with him that the problem was not solved by reviewing simply its technical aspects: it had become political. One aspect of the problem had been more emphasised than others during the last few weeks. At one time the discussion turned upon the various means of surface transit on the one hand and the Underground Railway on the other, and one seemed to be in a fair way to arriving at a solution of the problem by a consideration of the functions of these two forms of traffic. For the shorter and more casual traffic the omnibus or tram had advantages, while for people who had to make longer journeys to town the advantage lay with the Underground Railways. In the many discussions that had taken place they had hopes that they could have come to some agreement whereby their respective functions did not clash too much and a measure of co-ordination suitable to all concerned might be arrived at. But now they had reached a different point of view. The recent strike had shown that the three main forms of transit—trams, omnibuses and the Underground Railway—had different economic capacities. The tramways and omnibuses earned approximately the same amount of money for each mile they ran on the streets, in spite of the larger capacity of the tramways, yet the tramway represented an expenditure at least four times as great as that of the omnibus, and therefore it required four times as great a margin. The relative expenses of the vehicles were not sufficiently far apart to maintain that additional margin of income. Railways did not earn so much per mile as either the buses or the tramways, and their capital cost was at least 20 times as much as that of the buses, so they had to earn a still larger margin. It had been found that there was the greatest difficulty in securing that margin for the Underground Railways, and this difficulty had been evident before the Underground

Railways were grouped together in what was now known as the "combine." The railways so grouped had themselves different earning capacities, the District Railway, for example, had a different earning capacity from the Central London Railway. Yet these railways had approximately the same expenditure and relatively the same costs to meet, so that one of them might be prosperous and another not prosperous. It all seemed to point to the principles laid down by Sir Lynden Macassey that to meet this new difficulty they must have a common financial interest in London traffic so as to provide a complete solution. If the London Traffic Bill should go through it might be subject to improvement with time, as Sir George Hume hoped, and a proper control of traffic might be instituted. When that happy day arrived perhaps their own life would be more peaceful than now, and London not less well served than it was to-day. He congratulated Sir Lynden Macassey on his address.

Colonel J. A. A. Pickard (National "Safety-First" Association) said that in the last five years the number of street accidents in the Kingdom, excluding London, had increased by over 110 per cent., but in London, thanks very largely to the campaign carried on by the Safety-First Council the increase had been only 65 per cent. There was no doubt that the great increase in the number of motor vehicles in the last five years must very seriously aggravate the danger to be met. He thought that the driver of a motor vehicle was often unnecessarily blamed for accidents which occurred, and that in many cases of accident he suffered just as much as, if not more than, the person who was injured, because the blame was not his own. Anything that could be contrived to make the movement of London traffic more easy and more safe for the public was to be welcomed and if the Traffic Bill only brought them one step nearer to what might be the correct and logical solution they in London would be grateful for it. He would like to add a word in appreciation of Sir Lynden Macassey and his lecture. The speaker had been connected with London traffic for a good many years, and the report of the Royal Commission had been a "bible" to them all.

Chief Constable Arthur Bassom (New Scotland Yard) said that he had only just returned from Paris, where also the traffic conditions were very interesting, and he was quite unprepared to say anything of great point in that discussion. He would like, however, to utter two regrets that he felt on listening to Sir Lynden Macassey's paper and the discussion. The first was a regret that Sir Lynden should have scrapped his paper, because he felt sure that it would have contained a great deal of material which to Scotland Yard at least, would have been most instructive and would have given the cue upon which they might have obtained new ideas for the working of London traffic. His other regret was that the discussion that evening should have turned so largely upon one phase of the London traffic problem, —namely, the passenger carrying side. The London traffic problem was made up of many units, in which, he agreed, the passenger side played a very important part. But it was not the only part with which the police in regulating the traffic were concerned. He did not want at that late hour to enter into the various phases that made up the traffic problem, but he would have liked the discussion to have turned upon more general subjects, dealing with that problem as a whole, so that one could have crystallised the feelings of such an assembly as that and an indication could have been obtained as to the lines to be taken for the amelioration of the traffic difficulty. That difficulty, although accentuated at the present time, had been with them since the time of Charles I. Whether the problem was more acute now than it was in those days he was not old enough to say! But one knew quite well that in going through the various historical aspects of the London traffic problem, many attempts had been made to solve it, though nothing definite had been done, and it had been largely left to the efforts of the police to get the increased number of traffic units through streets which were not appreciably wider than they were 50 or 60 years ago. The traffic census which was taken year by year showed that the traffic units were increasing in number and in size. The average speed of the London traffic was also, by reason of the congestion, becoming lower than it was some years ago. He was not prepared to assent to the figure given elsewhere a little time back, but it could not be disputed that London traffic was becoming slower by reason of the greater congestion, and no real attempt had been made to increase the facilities for the traffic to pass through the given spaces. He thought that, instead of looking so far to the future, it was necessary for those who were dealing with the traffic problem to look first of all to the present and to consider what was required. The principal requirement was an immediate amelioration of the traffic problem. It was of no use trying to visualise what was going to be done by a Traffic Advisory Committee years hence. It was essential to get to work at once. There was one point he would like to touch upon with regard to Sir Alfred Yarrow's speech and his reference to the white lines painted across the road at intervals. He would like Sir Alfred Yarrow to take the idea for those white lines across to Paris and get them adopted there. Whether the white lines would ever be recognised by the average Londoner he did not know, but his experience, which covered a number of years, was that the average Londoner would cross the road at whatever place he wanted to, irrespective either of subways or of special indicating marks.

The Chairman (Lord Askwith) thanked Sir Lynden Macassey and indeed all the speakers for the most interesting remarks they had made. There were many things which occurred to him, but it was too late for him to elaborate them. One main issue was that it seemed that now and in

the past London had been extraordinarily conservative and had never got ahead with the facilities which it ought to have. A London had grown up through the ages, and its lines of buildings could not be altered without vast expense. There was present to their minds a mass of problems altering continually, changing even at different seasons of the year, which had to be coped with and required ingenuity and skill for their solution. There were certain broad lines which appealed to their intelligence. They all remembered a time when the horse was very prevalent in London, and he remembered how people before lunch, sitting in a Club in Piccadilly, would bet on the number of grey horses which would pass along Piccadilly in five minutes. To-day, one might wait almost for hours in Piccadilly without seeing one. He would not be at all surprised to find horses almost banned from the streets of London. It might be too, that in time the tramways would be eliminated and a much more mobile method of transit by omnibus or motor-car would be employed, without a fixed rail in the middle of the street. But even that would not offer a complete answer to the London traffic difficulty, because new phases of the problem were certain to arise. How would it be, for instance, when someone came down with a flying machine and desired to alight at a shop or to stack his machine at a cab-stand? With the progress of science and invention a great many more changes would take place, but at the same time they were very far behind, and if any general ruling up to a certain point could be attained within reasonable time, then at least, they would see either that they were going upon the right line or else upon a wrong line which they would have to reverse. It might be that they would have to come to dictatorship instead of having Advisory Councils; that might be the alternative to leaving the public to themselves without attention. As to Sir Alfred Yarrow's idea for crossing the street, he would rather like it to be tried in Paris first, as the last speaker suggested. He was not very hopeful of new directions of this kind. What was the fate of the "Keep to the Left" campaign? He heard an excellent speech from Lord Lansdowne who stated that as a law-abiding citizen he set out one day to try to keep to the left, with the result that he had never been more abused in his life than he was on that day. Could not Sir Alfred Yarrow present to the London County Council twelve movable bridges which could be clenched down and tried in some suburban crossings instead of being used in the first instance in Oxford Circus, where a good deal of opposition would be forthcoming? Such suburban crossings might gradually educate the Londoner up to the idea. He moved a vote of thanks to Sir Lynden Macassey.

The vote of thanks was carried unanimously.

Sir Lynden Macassey said that he thought he could best show his appreciation of their kindness by saying nothing more.

The meeting then terminated.

Mr. Arthur F. Evans writes:—

There have been numerous regulations, suggested or made, by the Governing bodies with the object of increasing the efficiency and safety of Road Traffic, but a "Rule of the Road," which should be the foundation of all these schemes has been denied all serious consideration.

I have already suggested a series of rules which I consider should be Statute Law, and the following rules I have selected as being the most important.

(1.) All vehicles shall keep to the left hand side of the road.

(2.) A vehicle shall keep clear of any other vehicle that may be on its left-hand side.

(3.) Traffic on main roads shall have precedence over all other traffic.

(4.) Traffic on all roads shall have precedence over traffic emerging from private drives, fields, farm yards, etc.

(5.) All vehicles altering direction or speed shall signal.

(8.) All vehicles shall carry lights in accordance with the classification and every vehicle (including cycles) shall exhibit a red light visible from all points behind the vehicle.

(9.) Pedestrians shall have equal rights to the road as vehicles, providing they comply with the rule of the road, except as regards lights and sound signals.

(13.) No livestock shall be allowed on the road unattended.

(14.) At night, those in charge of livestock travelling on the road shall carry a hand lantern, etc.

(17.) All other things being equal, the onus shall rest with the vehicle that has altered its speed or direction in case of accident.

I should like to point out that Rule (1) means *keep to the left*, not simply pass to the left, and Rule (2) is a development of this Keep to the Left Law. The latter provides the long-wanted direction in the case of two vehicles converging at cross roads, forks, etc.

Rule (3) was not really practicable till the roads were classified, while on the other hand the classification of the roads is of little value without this law.

The only laws governing the traffic at the moment are some vague "Laws of Custom" and local Police Regulations.

NOTES ON BOOKS.

Among the Wild Tribes of the Amazons. By Charles W. Domville-Fife. London: Seeley, Service and Co., Ltd. 21s. net.

Although one can steam in luxury two thousand miles up the Amazon, and in considerable comfort for another thousand miles, the fringe of civilisation on either side of the river is of the narrowest, and in many places a few steps will carry one into primeval conditions. A region about the size of Europe is still practically unexplored, and probably will long remain unexplorable. The forests,

which extend for hundreds of miles unbroken, are so thick that the traveller must hew his way through them; the rivers which flow into the Amazon are for the most part ridden with malaria and swarming with voracious monsters from alligators to mosquitos; while in the forests lurk tribes of anthropophagous savages, whose arrows and blow-pipe darts are dipped in the deadliest poisons.

This is the kind of country which Mr. Domville-Fife set out to explore. He made his way up various tributaries of the Amazon, generally in a canoe accompanied only by two natives. His principal object was to study certain tribes of whom little or nothing was hitherto known, and he succeeded in bringing back a great deal of information about them and some exceedingly interesting photographs. These were only obtained at imminent risk of his life. Apart from such dangers as malaria, beri-beri and other tropical diseases; the risk of running short of provisions or of losing his way in the forests, he found that in many places the natives viewed him with intense suspicion —a suspicion that had too often been justified by the brutal excesses of rubber collectors—and on more than one occasion he was within an ace of falling a victim to a club or a poisoned arrow.

The Amazon Valley is extraordinarily rich in timber and vegetation generally. *Inter alia*, it possesses many drugs which are hardly known to our pharmacopœia, but which the native medicine men use with considerable skill. A potion known as *yagé* is said to have proved exceedingly beneficial in cases of beri-beri, and it is also alleged that it produces curious telepathic effects in those that take it. Some of the tribes visited by Mr. Domville-Fife practise massage and physical exercises with remarkable results.

It is quite impossible to follow the author on his precarious journeys without a great deal more space than is available here, and without a map. It must suffice to say that he tells a story of intense interest in a graphic style. His descriptions of the great rivers which he explored, of the vast silent forests on their banks, with their wealth of vegetation and the amazing beauty of their flowers and butterflies, make up a volume which all lovers of travel will read with delight; nor will their appreciation be diminished by the fact that in spite of the many dangers which menaced him from the savage tribes he visited he left amongst them no one to mourn through the wanton crack of his rifle.

Jacquards and Harnesses: Card Cutting, Lacing and Repeating Mechanism. By Thomas Woodhouse. London: Macmillan and Co., Ltd. 25*s*. net.

The story of the Jacquard loom, or perhaps more strictly, the Jacquard system of control, takes us back about a century and a half to the young J. M. Jacquard whose tastes from childhood had been discursively mechanical. His parents left him an interest in some kind of weaving industry at Lyons, but he very soon failed and lost everything; apparently at this time having been engaged in what seems to have been regarded as an utterly mad scheme for controlling the loom action by perforated sheets of cardboard.

So the impoverished Jacquard became a soldier, and in 1792 he fought against the revolutionary army; but matters becoming more settled he renewed his labours with some success, and acquired a germ of fame, and one version of the story is that he was officially called to Paris, where he went in fear of being punished for his activity against the revolutionary party. On the contrary, he was received in a spirit of high appreciation by Napoleon, Carnot and other eminent persons; now his troubles were ended and he lived to see his method of automatic pattern weaving established as an industry at Lyons.

Mr. Woodhouse's magnificent volume of 430 large octavo pages, includes over 400 admirable illustrations in the text, many of these illustrations, like Fig. 267, being a number of illustrations grouped together, while others (Fig. 224 for example) represent complex machines with 50 or 60 references to parts. The work, however, is not of the nature of a general treatise on the Jacquard loom, nor is it in any sense a handbook of Jacquard weaving; its limitations being clearly indicated by the title. Some of the devices for controlling repeats, reversals and special adaptations are quite remarkable, and although the work is intensely technical, and moreover, departmentally technical to the weaving industry, all members of the Society may learn something from it as to general method and overlap of method on method under high complication. Remarkable and interesting combinations are involved in devices for weaving extra wide curtains, damasks, or comparable unit-systems or sheets, which often include direct and reversed aspects of the same device with repeats, overlaps, changes in the aspects of twilling and also a complete or four-sided border to each unit-system. A device of this kind, consisting of a broad loom, under the control of four Jacquards is represented as a back view on p. 70 (Fig. 45).

Applications of the Jacquard weaving system to Paisley shawls, plaids, carpets, multi-coloured tapestry and to many other textiles are considered and illustrated.

The general reader will get some notion of the surprising extent of the Jacquard industry at present, notably as replacing printing and expedients incidental to printing, like multiple mordanting, resists and discharges. The Jacquard weaver cannot fail to learn many new facts and notions, and manufacturers in other branches of the industry will be able to gather much as to economy of manufacture in its broad aspects. Although advertisements in technical books are unusual and perhaps generally undesirable, there appear to be excellent reason in this case for advertisement pages which in themselves indicate the present magnitude of the Jacquard industry.

X-Rays and Crystal Structure. By Sir W. H. Bragg and W. L. Bragg. Fourth Edition. London: G. Bell and Sons, Ltd. 21*s.* net.

In the preface to the present edition the authors refer to the difficulties of finding "words which remain suitable in the face of a succession of new researches." We may observe that this is a difficulty incident to all theoretical considerations based on rapidly progressing experimental work; but the mere fact of the authors having recognised this difficulty has evidently helped them to do much to render the work before us clearer in meaning than the greater number of books which deal with the theoretical aspects of experimental work. Language, at best, is very imperfect in relation to the higher branches of human knowledge.

The basis of those studies which have made the position of Sir W. H. Bragg so pre-eminent in modern scientific progress is the observation of Von Laue that X-rays can be diffracted like light, provided that we can find something of the nature of a diffraction grating but much finer than anything which can be produced by ruling, as for example a crystal. Thus it may now be considered as demonstrated that X-radiations are essentially, in their nature, similar to light but so extremely ultra-violet that the wave-length is very approximately about one ten-thousandth that of light (*i.e.*, real light or visual light); further the diffraction grating for this extreme ultra-violet must be of the gauge or measure or order of the distances of the molecules in matter.

By applying these principles in connection with known conditions by which X-rays lead indirectly to action on a photographic plate, the authors of this remarkable work lead us along devious and wonderful paths, and considerations more or less similar to Newton's concept of "fits" give us new and surprising views of matter and of molecular structure.

The diagram which represents the molecular concept of naphthalene tetrachloride (*p.* 253) affords an example of one aspect of progress; while the X-ray spectra of fatty acids (plate viii. *p.* 172) affords another aspect, and the crystalline structure of the diamond as represented on *p.* 100 exemplifies a third aspect.

MINERAL RESOURCES OF SOUTHERN HSINKIANG (Chinese Turkestan).

Southern Hsinkiang is exceptionally rich in valuable minerals and oil, none of which are exploited on modern lines and some not exploited at all. The following are worked in the order of their importance:—Jade, gold, copper, oil and coal. Other deposits which are known to exist but which are not, so far as is known, worked at the present date are:—silver, lead, iron, antimony, sulphur and mica. The following particulars regarding the minerals worked are taken from the Report by H. M. Consul-General at Kashgar on the trade of Chinese Turkestan in 1922-23:—

Jade. Jade is found in the micaceous and horneblendic schists of the Kuen Lun Mountains, whence it is carried down in lumps and pebbles of varying size by the Karakash, Yurungkash and Keriya Rivers. The people of Khotan, Keriya and neighbouring villages recover the stone in considerable quantities from the river beds; formerly it was mined *in situ* at an almost inaccessible spot in the gorge of the Karakash south of Khotan, but the mine has not been worked for many years and its very existence is now forgotten locally. There is no longer the free market for the product of the river beds that there used to be; most of it is taken up at prices fixed by themselves by the Chinese officials, and lumps of first quality translucent green stone seldom or never come into the open market. The white and dull green jades cost little in the uncarved state, the value being in the carving, which is done by artists at Peking. This work is not and has never been done at Khotan itself, where the stone is only worked into simple articles such as beads, bangles, cups, etc.

Gold. "Placer" gold workings of considerable importance exist at several places, notably at Surghak on the Niya River, 45 miles east south-east of Keriya and at Kapa, 25 miles south of Keriya. There are also workings at Chugullak and Chapchand in the same neighbourhood; the high snowy range, part of the Kuen Lun system, at the foot of which these mines are situated, being known as the Altyn Tagh or "Golden Mountains." The mines are exploited in a primitive manner by the Chinese officials through local contractors, who slave-drive the miners to such an extent that being sent to work in the gold mines is a common form of punishment for criminals in the Khotan and Keriya districts. The Chinese frequently have trouble with the contractor and the output varies accordingly; in a good year as much as 900 lbs. of gold is produced by an average of 2,000 miners. Nuggets of a pound or more are frequently found. Gold "placers" are also worked at an extremely lonely and desert place called Ak-tagh in the Karakoram, eight days' march south of Yarkand. This place is so inaccessible that it can only be worked for two months in the early summer, after the snow has melted and before the summer floods have reached their height, and then the miners have to bring all their food and firewood with them. Owing to the lack of pumping plant the output of these workings, which are continually being flooded, is small; but the gold-sand is very rich and if worked properly would yield large profits. There are also undoubtedly gold deposits in other parts of the mountains to the south of Yarkand, but the people keep them secret in order to prevent the Chinese starting mines and forcing the local people to work them.

Copper. Extremely rich deposits of red, black and green copper ores, from which pure metallic copper is produced by one smelting only, exist on the Terek river in the foothills of the T'ien Shan to the north of Kashgar and at Kanjigan, west-north-west of Kashgar. The "mines" are mere scratchings, as the Chinese who exploit them do not know how to carry their shafts to any depth, but even

so about 40,000 lbs. of the metal are produced annually and made into all kinds of utensils for the local market. Copper is also worked at Onbash on the Muzart river, 70 miles north-east of Aksu, while the ore is found near Kokya on the Yarkand-Ladakh road and in the Alai Mountains to the west of Kashgar. No one in Kashgaria has any idea of how to refine copper chemically.

OIL. The "Ferghana series" of oil-bearing strata extends into Kashgaria through Kanjigan, along the foot of the T'ien Shan, past Aksu and right up to Kuchar. The chief wells worked by the Chinese are at Kankjigan, Aksu and Kuchar; boring and chemical refining are alike unknown, the crude oil being scooped out of surface wells and holes. Even so, the strata are so rich that petrol, kerosene, machine oil, grease and mineral wax (ozokerit) of tolerable quality are all produced by means of primitive plant and used freely in the chief towns. Here again the exploitation and manufacture, such as they are, are kept carefully in their own hands by the Chinese. The chief refineries are those worked at Kashgar by the Titai (General Officer Commanding, Kashgaria) and at Aksu by the Magistrate.

COAL of fair quality, rich in coke, is found at Kanjigan, where shallow and primitive mines are worked by the Chinese. As only out-crops and weathered layers are mined, the coal is full of ash and is unsatisfactory for domestic use; but it would make an admirable fuel for metallurgical purposes. Coal exists at many other places in the province, but the only other mines worth mentioning in the southern part are near Aksu and in the Karatash Valley south of Yangi Hissar.

Beside the above minerals, the following are worked by the local Turkis and are always to be found in the bazaars: ozokerit (found in natural state near Kuchar and south of Yarkand; used extensively for candles); alum, sal ammoniac, gypsum. Good quality fireclay is found in the carboniferous strata and is extensively used by the natives in their smelting operations; it will be invaluable if and when the mineral resources of Southern Hsinkiang are ever properly worked. At the present the one idea of the local Chinese authorities seems to be to keep foreign enterprise out and exploit the minerals of the province for their own sole benefit.

GENERAL NOTES.

NEW PROCESS FOR MAKING WOOL FUR.—A paragraph under this heading appeared in the *Journal* of March 16th, 1923, reporting a newly invented process from Western Australia, whereby certain kinds of fleece can be manufactured into a rich fur-like material of remarkable warmth and lightness. A number of enquiries were received, asking where specimens of the material could be obtained. At that time there were no samples in this country, but the inventor, Mrs. Mary E. Southern, has now brought some over to London, and a collar and muff are on view in the Australian Pavilion of the British Empire Exhibition at Wembley. The process of manufacture is original and interesting, and the material, which should be obtainable in almost endless natural shades, appears to be as durable as it is attractive in appearance.

EMPIRE MINING AND METALLURGICAL CONGRESS. —This Congress will be held at the British Empire Exhibition on June 3rd, 4th, 5th and 6th, 1924. The Congress has for its chief objects: (a) The discussion of papers dealing with the scientific, technical, and economic problems connected with the development of the mineral resources of the Empire, and the mining and metallurgical industries. (b) The constitution of an Empire Council of Mining and Metallurgical Engineering Institutions, whose principal functions would be: (1) To serve as an Organ of intercommunication between the co-operating institutions, and to promote the interests of the professions and industries. (2) To create and maintain throughout the Empire a high standard of technical efficiency and professional status. (3) To convene successive Congresses within the Empire. (4) To establish, if it be found after discussion by the Empire Council and the co-operating Institutions to be necessary or desirable, a Register of British Mining and Metallurgical Engineers.

JACOBITE WINE GLASSES.—The large collection of English glass at present on exhibition in the Loan Court at the Victoria and Albert Museum has been further augmented by a fine collection of about fifty pieces lent by Mr. C. Kirkby Mason. These pieces (including two rare decanters) consist exclusively of glasses engraved with portraits, mottoes and emblems commemorative of the Jacobite cause, and date from the middle and second half of the 18th century. There are several unique specimens, and the collection as a whole worthily represents, not only the finest period of English glass-making, but also an interesting phase of English history.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

WEDNESDAYS:—

MAY 21, at 8 p.m.—(Trueman Wood Lecture.) SIR WILLIAM J. POPE, K.B.E., D.Sc., F.R.S., Professor of Chemistry in the University of Cambridge, "The Outlook in Chemistry." SIR HERBERT JACKSON, K.B.E., F.R.S., will preside.

MAY 28 (at 4.30 p.m.)—MRS. ARTHUR MCGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Indian Section.

Monday June 30, at 4.30 o'clock.—J. C. French, I.C.S. "The Art of the Pāl Empire in Bengal." The Right Hon. the Earl of Ronaldshay, G.C.S.I., G.C.I.E., will preside.

Dominions and Colonies Section.

Tuesday, May 27, at 4.30 o'clock.—C. Gilbert Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "A Sketch of the Geology and Mineral Resources of Cyprus." Dr. J. W. Evans, C.B.E., F.R.S., President of the Geological Society, will preside.

Monday, June 2, at 5 o'clock.—The Rt. Hon. Sir Frederick Lugard. G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member, Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates." The Rt. Hon. Viscount Milner, K.G., G.C.B., G.C.M.G., will preside.

Monday, June 16, at 4.30 o'clock.—C. V. Corless, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, May 19 Geographical Society, 135, New Bond Street, W., 8.30 p.m. Ahmed Hassanein Bey, "Through Kufra to Darfur."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. S. Perks, "London Town Planning Schemes—1666 and After."

University of London, University College, Gower Street, W.C., 5 p.m. Prof. G. D. Hicks, "Kant's Theory of Sublimity and Beauty." (Lecture II.)

5.30 p.m. Prof. Sir Flinders Petrie, "Recent Discoveries in Egyptology."

At King's College, Strand, W.C., 5.30 p.m. Prof. T. H. Bryce, "The Development of the Human Embryo up to the Appearance of the Primitive Segments." (Lecture III.)

University Extension Lectures, Gresham College, Basinghall Street, E.C., 6.15 p.m. Dr. A. Compton-Rickett, "Personal Forces in Modern Literature." (Lecture III.) Eugene O'Neill.

Tuesday, May 20 Statistical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.15 p.m. Dr. Major Greenwood, "The Mortality Statistics of Sweden and England and Wales—an International Comparison."

Anthropological Institute, at the Royal Society, Burlington House, Piccadilly, W., 8.15 p.m. Mr. S. Routledge, "The Austrel Islands and Mangarera, S.E. Pacific."

Transport, Institute of, at the Institution of Electrical Engineers, Victoria Embankment, W.C., 5.30 p.m. Mr. F. Bullough, "The Scientific Preparation of Railway Time-Tables."

Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. J. Barcroft, "Effect of Altitude on Man." (Lecture IV.)

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. H. Willford, "Some Methods and Results in Nature Photography."

University of London, King's College, Strand, W.C., 5.30 p.m. Mr. D. Subotić, "The Second Reign of Prince Milos" (1858–1860).

5.30 p.m. Prof. H. Bryce, "The Development of the Human Embryo up to the Appearance of the Primitive Segments." (Lecture IV.)

At the Imperial College of Science, South Kensington, S.W., 5.15 p.m. Dr. W. G. Miller, "The Pre-Cambrian—with special reference to that of Ontario." (Lecture II.)

Wednesday, May 21 Meteorological Society, 49, Cromwell-road, S.W., 5 p.m.

Literature, Royal Society of, 2, Bloomsbury Square, W.C., 5 p.m. Anniversary Meeting.

University of London, University College, Gower Street, W.C., 3 p.m. Prof. E. G. Gardner, "Problems of the Inferno of Dante." (Lecture I.)

At King's College, Strand, W.C., 5.30 p.m. Prof. L. T. Hobhouse, "Religions of the Empire."

At the Imperial College of Science, South Kensington, S.W., 5.15 p.m. Prof. Dr. P. Zeeman, "The Optical Effects of Motion."

Thursday, May 22 British Science Guild, at the Royal Society of Arts, John Street, Adelphi, W.C., 2.30 p.m. Annual Meeting.

London Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 5.30 p.m. Rev. A. G. B. West, "The Spirit of London."

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Structural Engineers, Institution of, 296, Vauxhall Bridge Road, S.W., 7.30 p.m. Mr. B. C. Davies, "Economics in Concrete."

Royal Institution, Albemarle Street, W., 5.15 p.m. Dr. E. V. Appleton, "Atmospheric Interference in Wireless Telegraphy." (Lecture II.)

University of London, King's College, Strand, W.C., 5.30 p.m. The Rt. Rev. the Lord Bishop of Manchester, "The Philosophical Pre-Suppositions of the Doctrine of the Incarnation."

5.30 p.m. Prof. A. J. Toynbee, "Outlines of Byzantine, near Eastern and Modern Greek History" (378–1841 A.D.). (Lecture V.)

5.30 p.m. Mr. A. Del Re, "English Influences in Italian Literature during the XVIII. Century." (Lecture III.)

Linnean Society, Burlington House, Piccadilly, W., 5 p.m. Anniversary Meeting.

Constructive Birth Control, Essex Hall, Essex Street, Strand, 8 p.m. Mr. H. G. Cannon, "Reduction in number of off-spring of Animals as they ascend the Ladder of Evolution."

Friday, May 23 Transport, Institute of, L.M. and S.R. Offices, Hunt's Bank, Manchester (N. Western Section). Annual Meeting.

Physical Society, Imperial College of Science, South Kensington, S.W., 5 p.m.

Royal Institution, Albemarle Street, W., 9 p.m. Dr. Andrew Balfour, "Historical Aspects of Malaria."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. W. L. Rea, "Wanderings in Northern Italy."

University of London, University College, Gower Street, W.C., 5.30 p.m. Miss M. S. West, "The Old Testament." (Lecture III.)

At King's College, Strand, W.C., 5.30 p.m. Dr. E. R. Bevan, "Ancient Ghost Stories and Theories about Ghosts."

Saturday, May 24 Royal Institution, Albemarle Street, W., 3 p.m. Dr. W. G. Alcock, "Musical Ornamentation."

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FRIDAY, MAY 23, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

TUESDAY, MAY 27th, at 4.30 o'clock. (Dominions and Colonies Section.)—C. GILBERT CULLIS, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "The Geology and Mineral Resources of Cyprus." DR. J. W. EVANS, C.B.E., F.R.S., President of the Geological Society, will preside.

WEDNESDAY, MAY 28TH, at 4.30 p.m. (Ordinary Meeting.)——MRS. ARTHUR McGRATH (Rosita Forbes), "The Position of the Arabs in Art and Literature." LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Further particulars of the Society's meetings will be found at the end of this number.

COUNCIL.

A meeting of the Council was held on MONDAY, MAY 12th. Present:— Lord Askwith, K.C.B., K.C., D.C.L., in the Chair; Sir Thomas J. Bennett, C.I.E.; Lord Blyth; A. Chaston Chapman, F.R.S.; Mr. Edward Dent, M.A.; Mr. P. M. Evans, M.A., LL.D.; Sir Robert Hadfield, Bt., D.Sc., D.Met., F.R.S.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Sir Herbert Jackson, K.B.E., F.R.S.; Major Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; Mr. Alan A. Campbell Swinton, F.R.S.; Sir George Sutton, Bt.; Mr. Carmichael Thomas; Dr. J. Augustus Voelcker, M.A., Ph.D.; Sir Frank Warner, K.B.E.; Sir Philip Watts, K.C.B., LL.D., F.R.S.; and Sir Alfred Yarrow, Bt., M.Inst.C.E., F.R.S.; with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

The question of the award of the Albert Medal for 1924 was further considered.

Preparation of the balloting list for the new Council was begun.

The entries for the June Section of the Examinations was reported. These are 43,838. The entries in April were 27,273, making a total of 71,111, as compared with 68,251 in 1923, an increase of 2,860.

Sir Thomas Holland, F.R.S., was appointed to represent the Society at the Franklin Institute Centenary Celebrations, and Major Percy A. MacMahon, F.R.S., to represent the Society at the International Mathematical Congress, Ontario.

Other formal business was transacted.

TWENTY-FIRST ORDINARY MEETING.

WEDNESDAY, MAY 14th, 1924; MR. ERNEST POLAND, Vice-President of the London Fur Trade Association, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Angle, Edward John, M.D., B.Sc., A.M., Nebraska, U.S.A.
Birch, Prof. T. Bruce, A.M., Ph.D., Springfield, Ohio, U.S.A.
Else, J., R.B.S., Nottingham.
Hansard, Colonel Arthur Clifton, C.M.G., London.
Henderson, Francis, J.P., Tunbridge Wells, Kent.
Hertz, Jacob, London.
Holdengarde, Theodore Albert Edward, Bulawayo, Rhodesia, S. Africa.
MacGallavry, Robert, Java, Netherlands East Indies.
Shehata, Nasif Girgio, Birmingham.

The following candidates were duly elected Fellows of the Society:—

Archibald, John Smith, Montreal, Canada.
d'Erlanger, Baron Emile Beaumont, London.
Drake, William Allen, Dayton, Ohio, U.S.A.
Flavelle, Sir Joseph Wesley, Bt., Toronto, Canada.
Fleming, Alfred, Southsea, Hants.
Garrigues, H., Copenhagen, Denmark.
Hodges, Gordon, London.
Izod, Edwin Gilbert, Johannesburg, Transvaal, South Africa.
Lynn, Scott, Mem.A.I.E.E., Toronto, Canada.
Nicholson, Reginald, M.B.E., Midhurst, Sussex.

Rai, H., Indore, Central India.
Whitby, Thomas Broom, Nottingham.
Williams, Frederic N., Shreveport, Louisiana, U.S.A.

A paper on "Furs and the Fur Trade" was read by MR. F. C. INGRAMS, President of the London Fur Trade Association.

The paper and discussion will be published in a subsequent number of the *Journal*.

PROCEEDINGS OF THE SOCIETY.

EIGHTEENTH ORDINARY MEETING.

WEDNESDAY, APRIL 9TH, 1924.

SIR FRANK DYSON, LL.D., F.R.S., Astronomer Royal, in the Chair.

THE SECRETARY said that Professor Vernon Boys, who was to have taken the Chair that night, was, unfortunately, unwell. The Society, however, had succeeded in securing the attendance of the Astronomer Royal, who had undertaken to fill the Chair at very short notice.

THE CHAIRMAN, in introducing the lecturer, said he was sure everybody would be extremely sorry at Professor Boys's absence. Professor Boys was the prince of experimenters. No one in the world was more capable of making beautiful and delicate experiments, and the audience, no doubt, would have liked to have his appreciation of Mr. Hope-Jones's clock. What Professor Boys would have had to say about it would have been of the greatest value and interest.

Personally, he was very pleased to take the Chair that night, although he might as well confess at once that his knowledge of the intricacies of clocks was very small. As an astronomer, however, he was much interested in the making of clocks, but he was afraid that he simply trusted to others to supply him with a clock, and then saw how it went. Astronomers had used clocks for 250 years. Up to that period they had got the time by observations of the altitudes of stars. Just before coming to the meeting he had looked up the record of Bradley's clock, and he had been very surprised to find how well it had gone. Its date was about 1755. It had gone between June 1st and August 31st with its rate changing only from a second to a second-and-a-half a day, and its rate changed from one day to another by about a tenth of a second. In recent times, a very great improvement in clocks had been made years ago by Riefler, but from what he had seen of the author's clock at Edinburgh, it seemed to be far ahead of Riefler's clock, and without more ado he would ask Mr. Hope-Jones to state how it had been done.

The paper read was:—

THE FREE PENDULUM.

By F. HOPE-JONES, M.I.E.E.

Exact measurement is the basis of scientific advance. The new Journal of Scientific Instruments recently established by various London Societies, has adopted this axiom as its watchword, and it is a truth which the Royal Society of Arts has always recognised. Last year's series of Cantor Lectures was devoted to precise measurements of length, and, whilst I can make no pretensions to such an exhaustive and brilliant treatise as that of Mr. Sears, the subject I am dealing with this evening is very closely akin to it, being the precise measurement of time.

Just 100 years ago Parliament made provision for restoring the standard yard, should it be lost or damaged, enacting that in this event a new standard should be made, bearing the same proportion to a pendulum beating seconds of Mean Time, in a vacuum at London and at sea level as 36 inches bears to 39.14 inches. Within ten years thereafter the Houses of Parliament were burnt down and the British standard destroyed, but the reference to the pendulum was found to be impracticable.

Thanks to the refinements of modern methods of measurement, we are able to satisfy ourselves that our national standards of length, when compared with one another from time to time, agree to within one part in two million, but that is no proof of their stability, as they may both be changing equally and imperceptibly. It is therefore highly desirable to find some "natural" or external standard as a basis of reference. Mr. Sears has put forward a proposal to refer his standards of length to the length of an Elinvar rod, which, when caused to vibrate longitudinally makes a definite number of vibrations per day. The success or failure of this method depends upon the continued constancy of the *modulus of elasticity* of the rod, its mass and its length.

If we look upon Mr. Sear's vibrating rod as a clock, it may be said that *ultimately* the constancy of its rate depends on the constancy of its *elasticity*, whereas the constancy of the rate of the ordinary pendulum clock *ultimately* depends on the constancy of the value of *gravity*. Which of the two has the higher order of constancy remains to be proved.

We, at any rate, are chiefly concerned with the type of clock which depends on gravity, and our efforts have been directed to eliminate the effect of the various subsidiary influences, and to make the time-keeping of our clock, as Professor Sampson,

the Astronomer Royal of Scotland, has put it, "as steady as the length of a rod," and dependent only on gravity. As we have succeeded in measuring time for considerable periods to within 100th of a second per day, or one part in 8 million of the time measured, representing a change of length of one part in 4 million of a pendulum rod beating seconds, it would appear that we have reached the limit of accuracy *if so defined*, and if we can maintain such a constant rate indefinitely—a very different thing to doing it for a month or two.

It may be asked, how do we know that we have achieved this rate? There is no standard in existence with which you can compare your clock to such a degree of accuracy from day to day, but there is, of course an ultimate standard of time based upon the rotation of the earth, and ascertained by transit observations of fixed stars. The methods of observing them, however, are comparatively crude. The transit circle observations, with automatic or semi-automatic travelling cross wire, give only a coarse and approximate reading, compared with the way in which we now record the performances of clocks. At the Edinburgh Observatory the recording instruments comprise an oscillograph and a cinematograph film with continuous motion used as a chronograph, which easily enables the clocks in the Observatory to record their beats to an accuracy of 1/1000th of a second, and they are commonly so recorded every day.

You cannot use stellar observations for a day to day test. When two clocks keep together to within 1/100th of a second for considerable periods, and the telescope frequently makes them wrong—sometimes to the extent of ± 1/10th of a second—one knows it is the transit observations which are at fault and not the clock. Such observations being admittedly 100 times as rough as the clock observations, you rate the clock from a long series of daily transits, of which you may require to take 100 to establish a straight datum line.

But in this matter Astronomers have had valuable assistance from wireless telegraphy, which now enables them to compare with one another the times of distant Observatories as determined by transit observation. This is done by means of the Rhythmic Signals or Time Vernier, first established by General Ferrié at the Eiffel Tower in 1911, and it enables distant clocks to be compared to an accuracy of 1/100th of a second. It has revealed some rather disturbing discrepancies, unaccountable and irregular; differences amounting to as much as ¼ of a second being frequently observed. This remarkable service has thus demonstrated the need for improvement in clocks of the highest order, and will doubtless exercise a powerful influence in that direction, just as on a lower plane the broadcasting of time signals is tuning up the watch and clockmaking profession, and improving the punctuality of the community.

I have said enough to remind you of the importance of precise time measurement, and to give you some idea of the degree of accuracy now demanded by the advance of science. It is in the nature of a race; accuracy of means of comparison has outstripped instrumental accuracy of both clocks and telescopes; and an effort is now being made to bring the clock up to scratch. Improvement is long overdue, for there has been no really important advance in horology for nearly 200 years, that is to say, since the days of Graham, Harrison, Mudge and Arnold, with the exception of Riefler, of Munich, of whom more anon.

Since 1895, when I read my first Paper in London at the British Horological Institute, I have approached this subject from a very definite point of view. My aim throughout has been to relieve the clock, or its pendulum,

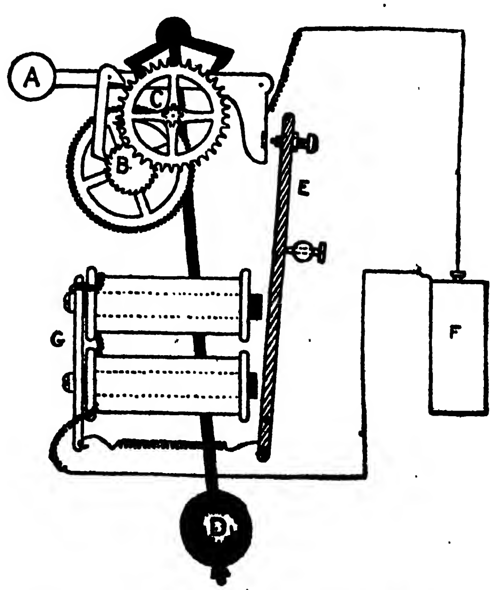

Fig. 1. The "Synchronome" Remontoire.

of interference. The first objects of attack were those innumerable contact applications intended to make clocks self-winding. In so far as energy was robbed from the clock, and was obtained at the expense of the time-keeping function, they were vicious, and had made electric clocks a byword for unreliability. That matter was successfully disposed of by using a cranked lever to drive the clock, lifting or resetting it by the armature of an electro-magnet in the manner shown in Fig. 1.

The weighted lever A as it falls turns the wheels B and C and keeps the pendulum D swinging. When it reaches the armature E the circuit of the battery F is closed, and the electro magnet G replaces the weight by throwing it up on to the next tooth of the ratchet B. The feature of this arrangement was that no energy was taken from the clock, yet inasmuch as the whole of the driving force was transmitted through the surfaces of the contact, its reliability was assured.

That brought us, at the beginning of the century, to the point of being able to say that clocks were no worse for being electrically re-wound, in fact, as the re-winding was frequent and the drive constant, they were perhaps a little better. Incidentally the remontoire action constituted an excellent switch for the operation of circuits of electrical impulse dials, but that has nothing to do with us now, excepting only this, that it exercised its influence towards breaking away from the stereotyped forms of escapement. The vision of the clock-maker had been bounded for a century or more by escapements. Pin wheel, anchor, half dead-beat, dead-beat and gravity, all had been analysed and tried out to the very end. The Graham dead-beat emerged as the best for precision timekeeping.

The limit of accuracy had apparently been attained; an impasse had been reached, and there was no room for further theorising or experimenting.

It appears to have been taken for granted from the earliest days of clockmaking, that it was desirable, or perhaps necessary, for the impulse to be imparted to the pendulum at every swing. In explaining how it has been found possible to free the pendulum altogether, I shall show you that it is neither desirable nor necessary to give frequent impulses, and that electrical time circuits of half-minute periodicity have contributed materially to the breaking away from a hide-bound custom.

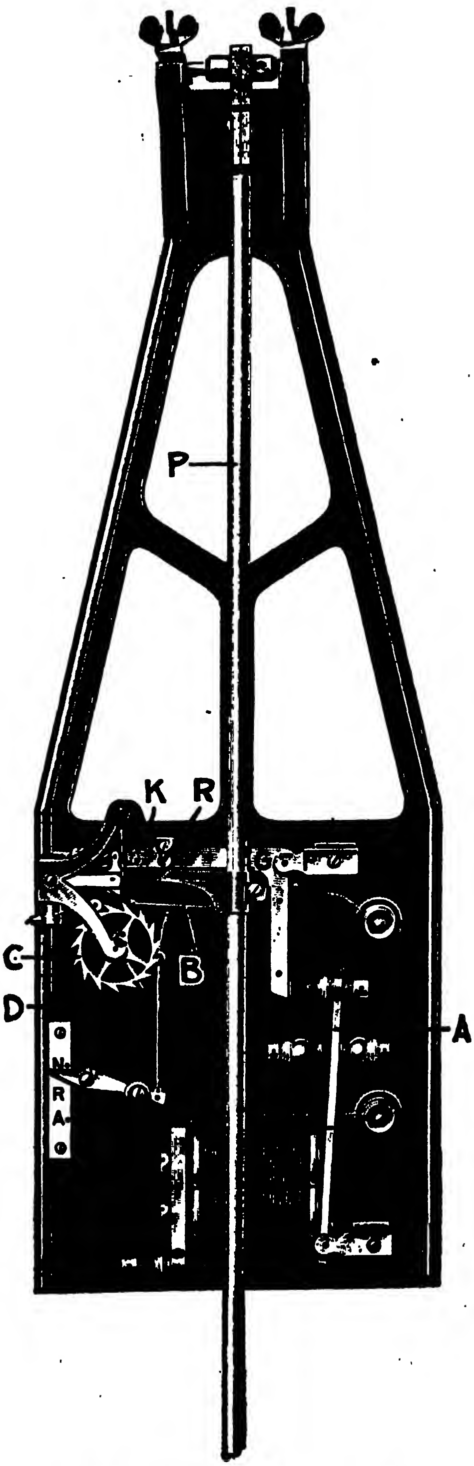

Fig. 2. The "Synchronome" Switch.

There are, of course, two sources of interference with the natural swing of a pendulum; firstly—the very word "escapement" implies it—the releasing of stored power in small instalments; the energy expended by the pendulum in that act of release may be variable; secondly, the impulse itself when given must necessarily interfere to some extent with its free swing.

The first can be dispensed with altogether; the second may be rendered innocuous by imparting it to the pendulum when the latter is passing through its zero position.

To understand how this is done, it is necessary in the first place to master thoroughly the action of this simple electro-mechanical device known as the Synchronome switch, illustrated in Fig. 2. It is a combination of a pendulum and a switch. The pendulum tells the switch when to work (usually every half-minute), and the switch imparts an impulse to the pendulum when it falls.

The switch consists of two moving parts; the right-angled lever G and the magnet armature A resting against stop E. The right-angled lever G is centred at F and normally supported on the spring catch K. Once every half-minute the lever is released, and, after giving impulse to the pendulum, makes contact with the armature, with the result that an electric current passes through magnet M, which accordingly attracts armature A, and throws the lever G up on to its catch again. A number of electrical impulse dials are usually included in this circuit.

If the current is insufficient the armature does not move, and the circuit remains closed until the pendulum on its return swing comes to the assistance of the magnet. This abnormal increase in the time of contact is utilised to give a visible or audible warning of the impending failure of the battery, by lighting a lamp or ringing a bell. The pendulum will usually continue to operate under battery warning conditions for some days, and only ceases to do so when the current has got so low that magnet plays practically no part in the lifting of the lever.

The pendulum releases the switch by means of the 15T wheel C and the vane D, which engages with the catch K at each revolution. The hook B, pivoted upon the pendulum P, rotates this wheel one tooth at a time once every thirty seconds. L is a backstop.

Impulse is given to the pendulum by the little roller R, attached to the gravity arm, running down the curved end of the pallet J fixed to the pendulum. At the moment of release the sloped face of the pallet has just *not* passed under the roller, and the pendulum has just not reached its mid position. Thus the impulse is given while the pendulum is passing through its mid or central position, and the pendulum is quite free at the ends of its swing. The escapement is, therefore, not only detached, but operates at zero, and thus fulfils the horologist's ideal.

The shape of the impulse face of the pallet J has been determined mathematically, so that the impulse commences very gradually, increases to its maximum at zero and then decreases in an identical manner.

When the switch is used to operate circuits of electrical impulse dials it is called a master clock, and is designed so that its minimum operating current is more than that required by any dial or other instrument in the circuit, and, as all the operating magnets are in series, it follows that the circuit has considerable self-induction, and that the current takes some hundredths of a second to attain its full value. Consequently, it is impossible for the switch to operate without supplying sufficient energy to the various dials to propel them.

I demonstrated this by oscillographs in my 1910 Paper, before the Institution of Electrical Engineers, one of which is reproduced here. It may be described as a photograph of one of the Synchronome half-minute impulses. The small depression

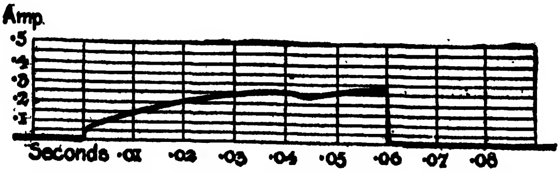

FIG. 3. Oscillograph of Synchronome impulse.

between .04 and .05 seconds represents the operation of the dials, and the area enclosed between the curve and the base line represents the quantity of electricity consumed per impulse, which in this case is .012 coulombs, and, since the impulses are repeated every half-minute, this equals about 3½ amp. hours per annum. As each dial requires about 1½ volts across its terminals, the annual consumption of energy per dial is about 5½ watt hours.

As the voltage of the battery drops, the duration of the contact increases, the energy consumed remaining practically unaltered; consequently a very considerable drop must take place before the switch commences to indicate failing battery.

The oscillograph test, which will infallibly reveal the slightest intermittency or raggedness of impulse, demonstrates the perfect cleanliness and precision of the make and break, cardinal virtues not easily obtained.

It will be observed that the energy devoted to making a good and reliable contact is considerable, but it is not taken from the pendulum. It comes from the electro magnet, being, in fact, the whole of the energy developed by that magnet, and it is all mechanically transmitted through the surfaces of the contact.

All that the pendulum has to do is to count out the half-minutes (by pulling round an idle wheel), and to release the catch supporting the gravity arm.

If only these two duties could be done for it, then we could truthfully call it a free pendulum, subject to no interference whatever, excepting only that which is inevitable and inherent in the act of impelling it. Is this possible? For long enough it seemed so impossible that no one even asked for it. After all, we can hardly blame clockmakers for not inventing an escapement which does not escape.

The idea is to employ a subsidiary instrument—some extraneous mechanism—charged with the duty of releasing the gravity arm, and that this instrument should be dominated or controlled in some way, so far as time-keeping goes, by the free pendulum. Thus, if perfect phase synchronisation could be maintained between two pendulums, one could be employed to perform the duty for the other.

At first view it is not easy for a person of average intelligence, even though he may have the mechanical instinct and be well versed in clock escapements, to understand how it is possible for a free pendulum, which is not allowed to touch anything, or to do any work whatever, to communicate synchronising impulses to another. In saying "Not allowed to touch anything" I was not quite correct, for it is touched by something, viz., a falling gravity lever, which imparts an impulse to it. Advantage is taken of the fact that the exact point of time at which the impulse terminates is determined by the pendulum, and, the impulse being over, the gravity arm in its further fall is employed to give the synchronising signal. It is with a view to simplifying this explanation that I have had to tax your patience to acquire a thorough understanding of the Synchronome switch.

Refer to Fig. 2, and consider for a moment what determines the precise instant at which contact between G and A occurs. It is, and always must be, dictated by the pendulum in its passage from left to right, after receiving the impulse. Assume for a moment that we have found some means of releasing the gravity arm G without the aid of hook B, wheel C and vane D, then let us establish our free pendulum and apply such a gravity arm catch and magnet to it. The gravity arm being released by some means, delivers its impulse to the pendulum, and the resetting of it (in other words, the remontoire or switching operation) will take place, as we have seen at a point of time dictated by the free pendulum itself.

Obviously, therefore, we have in this switching operation a synchronising signal of absolute precision, obtained from the free pendulum without affecting it in any way, and with regard to the impulse which is the immediate preceding cause of the operation, it only affects the free pendulum in so far as any impulse not absolutely concentrated as a blow delivered upon it when passing through its zero point, may rank as a possible disturbance to its natural period of vibration.

The diagram, Fig. 4, in which the same reference letters are used as in Fig. 2, shews the arrangement and inter-connection of the two clocks. It will, of course, be understood that in the free pendulum the catch K, which holds up the impulse lever, is released by an electro magnet at the moment the impulse pallet reaches precisely the right position. This magnet (which substitutes the count wheel and releasing mechanism of the standard switch movement)

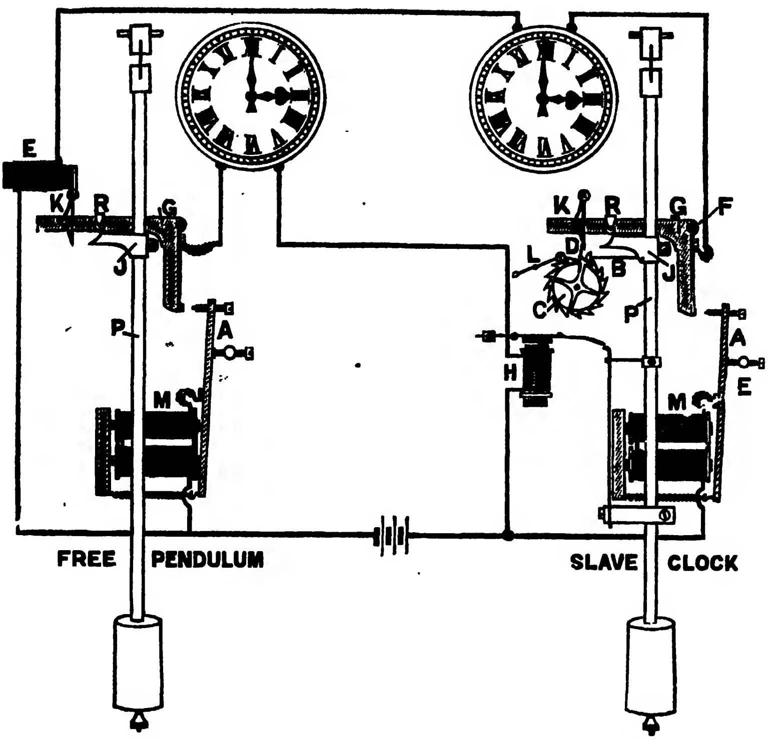

FIG. 4. Circuit diagram of Free Pendulum and Slave Clock.

is connected in the remontoire circuit of the slave, while the slave is synchronised through the agency of another electro magnet connected in the remontoire circuit of the Free Pendulum.

Just as the remontoire of the free pendulum operates the synchronising magnet on the slave every half-minute, so the remontoire of the slave operates the releasing magnet of the free pendulum's gravity arm every half-minute, and the effect is that one pendulum measures time and does no work, whilst the slave does all the work and has its precise timing done for it, a very satisfactory mutual arrangement.

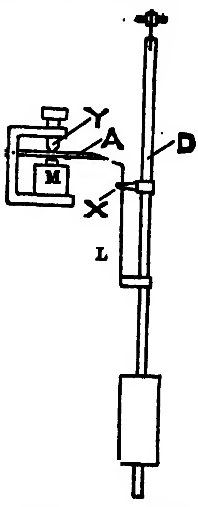

FIG. 5. The "hit or miss" Synchroniser.

The synchronisation of the slave pendulum is achieved by means of the device illustrated in Fig. 5.

The synchronising electro magnet M is fixed adjacent to the slave pendulum D, so that its armature A is horizontal, and will, when attracted, just engage with the upper end of the springing vertical lever L attached to the slave pendulum, as the latter passes through its mid position, the engagement only being possible when the pendulum is swinging from right to left.

When this engagement takes place the continued movement of the pendulum bends the springing lever L and calls into play a force which assists gravity, and consequently accelerates that particular half swing by a small fraction of the period of vibration. X and Y are stops against which L and A normally rest.

The slave is given a small losing rate of

about 6 seconds a day compared to the master, and is started up so that when swinging from right to left the operation of magnet M by the remontoire contact of the master pendulum movement is just too late for A and L to engage. Then, as a result of the losing rate, the phase difference of the two pendulums will gradually decrease until engagement finally takes place, with a consequent advancement of the phase of the slave corresponding to the quickening action of the spring. As this quickening action is arranged to be about twice as great as the amount lost by the slave during the interval in which it is undisturbed, it follows that at the next impulse the slave will not have dropped back quite enough to permit engagement by the electro magnet and a miss will occur; by the end of the next half-minute, however, the phase difference will be approximately the same as when the initial engagement took place, and a second engagement will ensue with a corresponding quickening.

This cycle of operations will obviously continue indefinitely, and the phase difference between the master and slave will not be allowed to vary by more than plus or minus the advancement produced by one operation of the spring. A losing rate of 6 seconds per day equals 1/480th of a second per half-minute, so that the quickening action of the spring need not exceed 1/240th of a second, and the phase difference of the two pendulums will never exceed plus or minus this amount. As long as the losing rate of the slave relative to the master does not increase to more than 12 seconds per day, nor decrease to less than zero, it will be held in phase with the master, and it will be agreed that the above limits of rate are amply sufficient to warrant the statement that the control of the slave by the master is complete.

It should be mentioned that the impulse roller and pallet are arranged in the master, or free pendulum, somewhat differently from that shown by the diagram Fig. 4, and the drawing Fig. 2, in order that the termination of the impulse may be independent of the drop of the lever, and dependent only on gravity and the arc of the pendulum.

Having thus relieved the pendulum of the last vestige of its duty, let us now consider the extent to which the impulses we impart to it are likely to interfere with its natural period of vibration. They are, of course, constant in value—uniform weight falling uniform distance. They are concentrated as far as possible at the centre of its path where its velocity is greatest. If this concentration were complete, the interference would not affect its natural period of vibration at all. If the duration of each impulse is about the 1/10th part of a second, and occurs only once in each half-minute, it represents 1/300th part of the time measured. Compare this with existing clock escapements, where the duration of the disturbance is either continuous or of the order of 50 per cent., or one second out of every two.

Nevertheless, "impulsing" is the one source of possible disturbance, and must be reduced to the absolute minimum. With that object and also with a view to cutting out the whole set of complex considerations involved in variation of air density, we proceed to exhaust the case from the normal of 760 mm. to about 30 mm. of mercury, by enclosing the whole free pendulum in an airtight case and pumping it out.

This reduction in pressure reduces the pendulum friction practically to that of the flexing of the suspension spring, and enables the normal arc to be maintained with an impulse lever of about 1/5th of the weight that would be required had the air been left in the case at atmospheric pressure. An arc of 100 minutes is maintained by a weight of .43 grammes falling 2.0 millimetres once every half-minute, the equivalent of about 1/8th foot-lb. per week. One seldom puts less than 50 foot-lbs. into the grandfather clock on Saturday night.

Of the stagnation of clock invention for nearly 200 years I have already spoken. The only other developments in that period which occur to me as worthy of mention are the Grimthorpe gravity escapement and Riefler's clock. The former has been a conspicuous success on turret clocks, for which it was designed, but it has not otherwise contributed to the science of accurate time measurement. The latter, on the other hand, has been adopted to an increasing extent in the world's observatories for the last thirty years, and held all the records until beaten at the Edinburgh Observatory last year. Briefly described, the top chops and trunnion are rocked on knife-edges coincident with the axis of suspension. By this means the impulse, derived from an escape wheel, is transmitted to the pendulum through the suspension spring. For a

short distance beyond zero the spring is straight, the pendulum and trunnion swinging together on knife-edges, then the scape wheel delivers its impulse to the pallet and rocks the trunnion back a little, locking it there, and thus imparting its impulse through the spring.

Of course, it is not a free pendulum, though at first sight it appears to be, but the evils of interference are greatly reduced by avoiding all mechanical contact with the pendulum below the point of suspension.

The credit for the general idea of this division of labour by the employment of another clock must be accorded in the first place to Mr. R. J. Rudd, of Croydon, who accomplished it in the year 1898, but he hid his light under a bushel, and though he published a short description of it, it was never discovered by anyone competent to express the theory, and to turn his application of it to practical use.

A year or two later, in ignorance of Rudd's work, the late Sir David Gill attempted it in a clock for the Cape Town Observatory. He failed, but he was the first to speak of a "slave" clock. Mr. C. O. Bartrum, of Hampstead, in ignorance of both, patented a method of free pendulum and slave in 1913, and Father O'Leary, S.J., of Dublin, patented one in 1918. But I have not heard of any attempt to develop these inventions or to test their possibilities.

The principles involved appear to me to have been very inadequately dealt with by these inventors, and it is doubtful whether any of them appreciated fully the advantages inherent in this division of labour. Also, their electro-magnetic and/or mechanical apparatus usually transgresses one or other of what may now be laid down as two fundamental precepts, that just as the right time to impart impulse to a pendulum, with a view to minimum interference with its natural rate, is when it is passing through the centre or zero position at its maximum velocity, so the right time to synchronise it, i.e., to apply maximum interference to its natural rate, is when it is at the end of its swing and its velocity is at its lowest.

When once stated, these principles are perfectly obvious, but they have neither been realised nor expressed before, and I think there has been a tendency in our horological schools to adhere too closely to the text books on clock escapements, instead of looking beyond them with a wider vision and using them to illustrate great truths and natural laws.

These principles have not been easy to realise. The first, the delivery of impulse at zero, was achieved by Arnold and Earnshaw in the chronometer detent escapement 140 years ago. Many attempts have been made to apply the same method to a pendulum by those who appreciated the fact that none of the recognised clock escapements leave the pendulum free at the ends of its swing. Several people did it, but success being measured by adoption rather than by grace, the one to be mentioned is that of Sir Henry Cunynghame, who accomplished it with a mechanical escapement in 1906, which he assisted me to incorporate into the Synchronome System.

The second, however, the theory of synchronisation, is comparatively young as a problem, as it involves the use of electrical impulses, and this subject has been greatly neglected and misunderstood. A chronicle of attempts would reveal many blunders. One veritable stumbling block has been the confusion of indicated error and error of rate, two very different things. The synchroniser above described and the method of using it in combination with the Synchronome system to produce the free pendulum, is the invention of Mr. W. H. Shortt, M.Inst.C.E., who has been carrying out research work on high grade time-keeping since 1910. We had both been seeking a solution of this particular problem since I saw Rudd's clock at Croydon, and many methods were patiently tried out and discarded. I want to bear testimony to Mr. Shortt's ability in the conduct of patient and systematic research which has won for him the blue riband of our Turf, that is to say, a record of a higher degree of time measurement than any that has yet been achieved by man.

Synchronization involves two things, first a comparison, and then a correction. In Mr. Shortt's synchronizer the comparison is made when both pendula are at zero. It is then, immediately after impulse has been delivered, that the free pendulum transmits the comparing signal and it is when the slave clock is also at zero that it receives the signal and makes the decision as to whether or not acceleration is required. The correction, if it is made, takes place when the pendulum is on its half swing to the left, out and home, the action thus

completely embracing the extremity of the swing which is where interference disturbs the pendulum most.

Before discussing the performance of the clock as recorded on the rate chart, let me sum up briefly those features to which I attribute the success achieved :—

There is NO INTERFERENCE with the pendulum's natural period of vibration, that is to say, it has nothing to do but to swing.

The IMPULSE is

(1) Uniform in value ;

(2) Delivered at or about zero ;

(3) Small in quantity ;

(4) Imparted occasionally, *i.e.*, at wide but regular intervals.

It is in a VACUUM which makes (3) and (4) possible, and eliminates all barometric considerations.

It is erected in a room kept at CONSTANT TEMPERATURE, because although the pendulum itself is compensated with the greatest thoroughness and care, the compensation can never be sufficient of itself.

It has only been possible to realise the

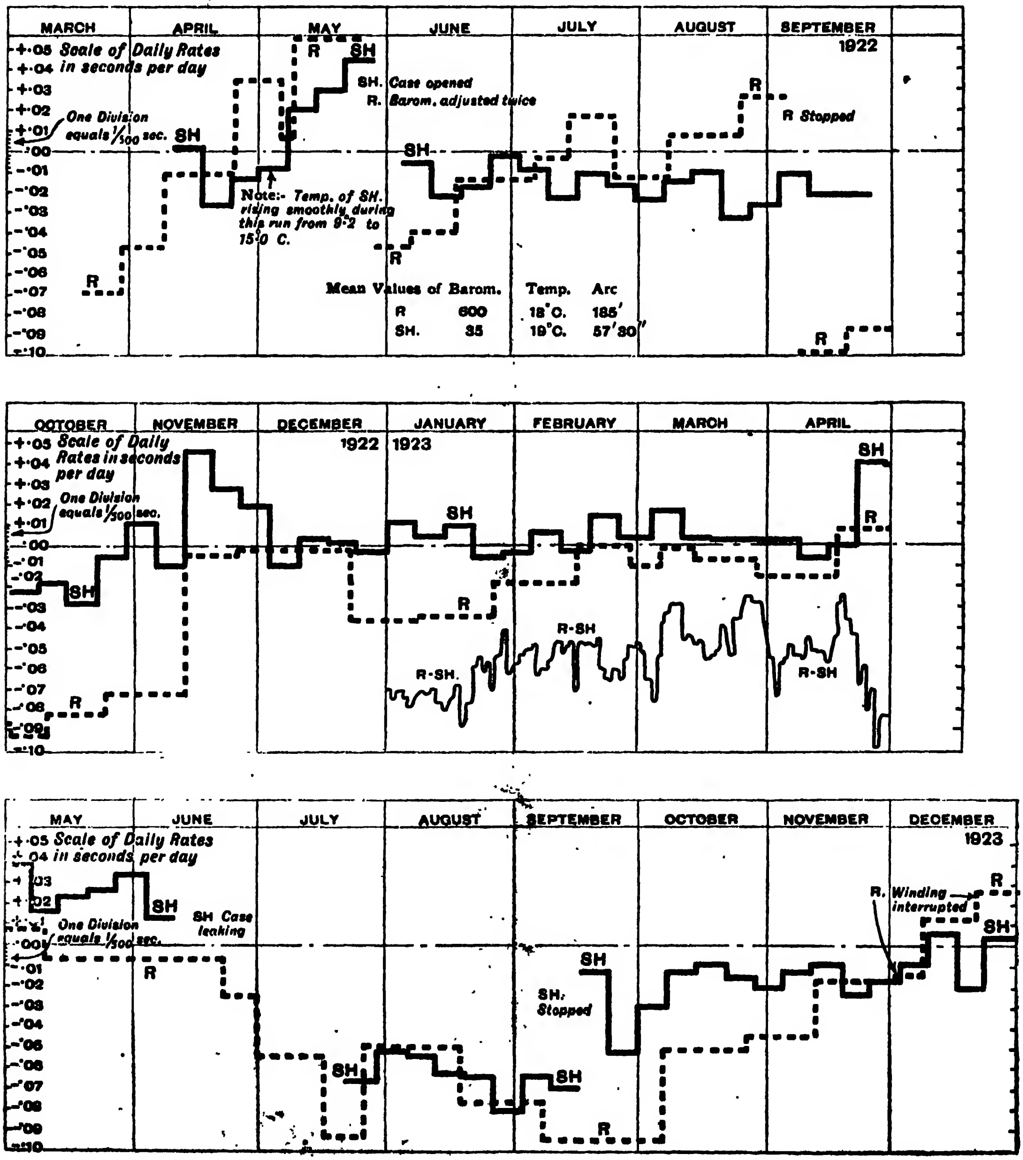

FIG. 6. Rates of Clocks Shortt (Synchronome) and Riefler, plotted from figures given in Professor Sampsons' Paper, R.Soc. Edin. January 14th, 1924.

above conditions by means of the Synchronome system, which had already met most of them and what is more important had proved its reliability up to the hilt. Not until a system has "worked out its salvation in fear and trembling" by public use in competition can it be trusted for the responsible work of an observatory. Astronomers cannot afford to waste time and money in experimenting and they would be particularly disinclined to do so in the case of electric clocks in whose name so many crimes have been committed.

The experience we have had of this clock since 1921, added to the obvious moral to be drawn from the success of Riefler's, has led me to the firm conviction that, for precision timekeeping, escapements are dead.

For this experience of the running of the clock we have had to thank Professor Sampson, the Astronomer Royal of Scotland.

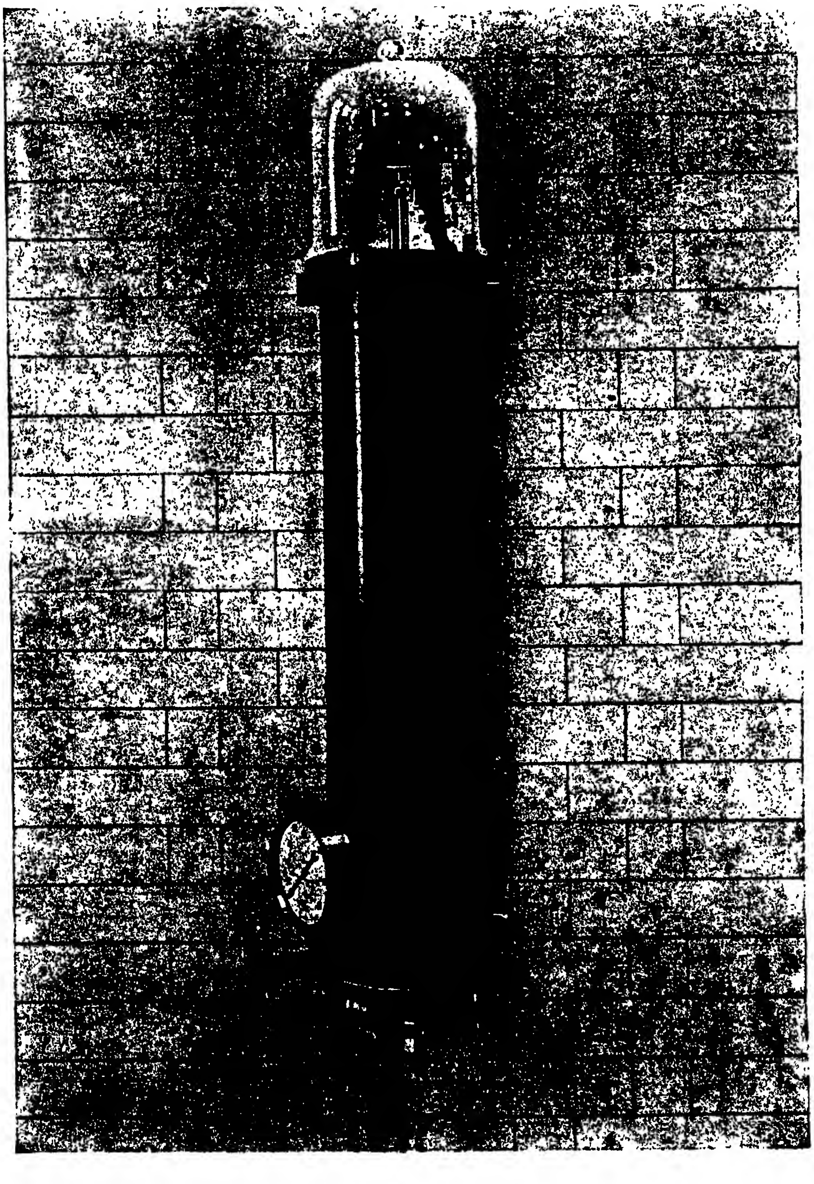

FIG. 7. Free Pendulum in Vacuo.

Since 1918 he has been contributing a series of papers to the Royal Society of Edinburgh on timekeeping. These and other contributions to the Proceedings of the Royal Astronomical Society in description of his special apparatus installed at the Edinburgh Observatory, have placed him in the forefront among the astronomers of the world as having specialized on accurate time measurement. His instruments at Edinburgh comprise an oscillograph and a cinematograph film with continuous motion used as a chronograph having the 10th parts of a second automatically recorded on the strip by means of a vibratory tongue over a window slit obscured and revealed at each vibration. With the use of a reading microscope the record is measured to the thousandth of a second. All the clock records appear on this strip.

I exhibit on the wall a chart (Fig. 6) produced with his permission from his last Royal Society of Edinburgh Paper. On it are plotted the rates of the Free Pendulum in red (black line) and of Riefler No. 258 in blue (dotted line). This particular Riefler has acquired some fame as probably the best ever produced by that firm. It is, of course, far superior to the best Graham dead beat escapement clock. I must here emphasise the unusual scale upon which the rate chart is drawn. If the horizontal divisions had been made to represent seconds as is customary, the curve would be so flat as to lose all interest—as flat as ditch water. It is doubtful if you could see any deviation from the zero line. And even if we multiplied the vertical scale by 10, so that each division represented a 10th of a second, it would still be too small a scale to express the facts clearly; the curve would lie entirely within one division. So we multiply by 10 again, using widely spaced horizontal lines, each space between them representing 1,000th of a second.

Owing to imperfections of transit observations, the problem of clock comparison on this high plane of precision is an exceedingly difficult one. Professor Sampson expresses the problem as follows:—"Given a number of clocks, A, B, C, . . . compared regularly, frequently, and accurately with one another, and compared also at irregular intervals, sometimes entailing long gaps, with the much rougher final stellar standard, to ascertain precisely what is happening in any interval." Professor Sampson treats the problem in this way: "The simplest plan, and that which I have taken, is to adopt one clock as director. The errors which are indicated by stellar observation for the director are charted just as they are observed, on every practicable night, without any smoothing whatever. Against these are also set the relative going of the director and each of the other clocks as shown by the microchronograph. The former chart may often run as a set of improbable zigzags. The latter will indicate reliably all sharp changes of relative rate that actually occur."

This method is open to the objection that if one of the other clocks was actually going better than the director, it does not get justice done to it, but is debited with the director's faults. Professor Sampson gives several instances of this, and I need hardly say that I believe our rate to be steady, that our line, to be truthful, should be a straight one and that the variations are the other fellow's; further, that it will so be proved when the free pendulum is elevated to the position of the director in the Edinburgh Observatory.

Now a few words with regard to nomenclature. New inventions require new names; the inventor coins them and their currency depends upon their utility. I have coined one, the Synchronome Switch, because it seemed to me to be a fundamental device possessing a number of distinctive qualities—a device which is likely to be used in different ways for different purposes; therefore, a single word to express it and its inherent virtues will be a convenience.

The word Slave, first used in this connection by the late Sir David Gill, is obviously appropriate as applied to the pendulum synchronously coupled to the Free Pendulum to perform the releasing function for it. This might lead one to speak of the Free Pendulum as the Master, but it must not be forgotten that what we now use as a Slave has been customarily regarded as a Master Clock, and will still remain so in so far as it is a transmitter of electrical impulses for the purpose of operating circuits of electrical impulse dials. When it is so used perhaps the term "Transmitting Slave" will be more appropriate than Master Clock.

Any number of transmitters can be controlled by a Free Pendulum and there is absolutely no limit to the contact making and switching operations which a Slave may perform without affecting the Free Pendulum even indirectly. A slave clock will operate

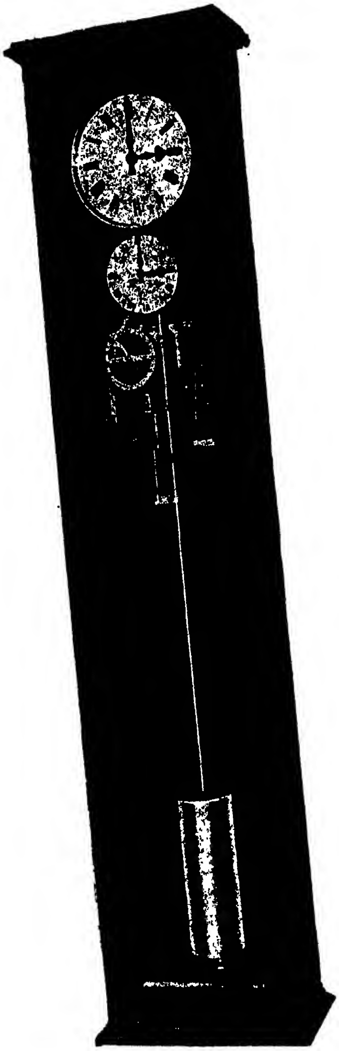

FIG. 8. Slave Clock.

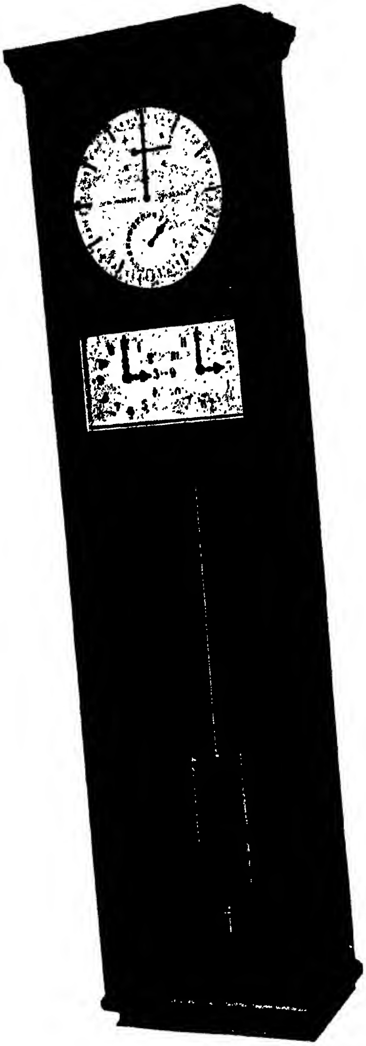

FIG. 9. Slave Clock indicating seconds.

circuits of electrical impulse dials, including turret clocks, just as well as chronograph pen magnets and seismograph recorders, and if the Free Pendulum is a Sidereal, it may control the motion of telescopes used for stellar photography.

It is also a great convenience to be able to set the clock to time. Hitherto it has not been possible to set to time clocks sealed up for constant barometric pressure without breaking the seal. A feature of the Free Pendulum which will be highly appreciated by astronomers is that the slave clock (its only time indicator) can be readily set either forwards or backward, the only limitation is that it cannot be set less than two sceonds either way, that being the period of vibration of the Free Pendulum which, of course, is never touched.

Time has not permitted me to deal adequately with other methods of maintaining and counting the vibrations of a Free Pendulum. I had to choose between an historical and a practical lecture, and I chose the latter, but I must remind you that it can be and has been done by radically different methods, such as by means of a selenium cell, and also by means of the Triode valve. I have, however, found these proposals to be deficient in the counting

and switching functions, which are of the utmost importance, and for this and many other reasons I prefer my own methods.

DISCUSSION.

The Chairman, in opening the discussion, said Mr. Hope-Jones had given an extremely lucid account of what he himself, at any rate, found rather a difficult subject. One thing about which he felt very strongly was that the author's clock, and the rates which were shown to have been got at Edinburgh, certainly met—and very much more than met—all the requirements of astronomers at the present time. The difficulty of the astronomer was with his instrument; there were questions of stability of his mounting, possibility of flexure in the axis, and so forth, and under those conditions, with such instruments, astronomers did not get anything like as much precision as they did with clocks.

Mr. C. O. Bartrum said that he had recently spent an afternoon at the Edinburgh Observatory, when he had been very much impressed by Mr. Shortt's clock. To see the dream of his youth actually realised before him was quite moving. He had been greatly flattered to find that the humble effort which he had made in 1917, to which the author had made reference in his paper, had been proved by Mr. Shortt's results to have been on the right lines in so very many ways. Unfortunately, his clock had been left in a rough model, and it had never been realised as a properly made instrument. It was rather curious that so many investigators had been working on the same idea without knowing of each other's efforts. For instance, he had never heard of Rudd's clock. When he designed his clock he thought that the slave principle was absolutely new, but he had found that it was quite an old idea. He was pleased to find that Mr. Shortt had dropped his inertia escapement; he had always felt it was wrong. What Mr. Shortt had done was to remove the symptom of a complaint without remedying the disease itself. On one occasion he had ventured to correspond on the subject, and he had to confess that Mr. Shortt had given him a very clever and charming reply which had made him feel rather uneasy.

He considered that Mr. Shortt's clock marked an epoch in time-keeping, and he thought the lecturer had convinced the audience of that fact. Genius was here shown as a combination of simplicity and efficiency, but genius had also been defined as an infinite capacity for taking pains. Mr. Shortt had shown this too by the way he had studied every detail with such care. After all, the carrying out of details and the way in which an idea was developed, was almost as important as the actual idea itself. That was exemplified by the reference which Mr. Hope-Jones had made to the Leroy clock at Edinburgh. Mr. Hope-Jones had described the escapement—a very commonplace idea; it was based on the principle of the old Mudge gravity, but it was so beautifully carried out and made, that the clock was only second to Shortt's, and better than the old Riefler.

He believed it would be agreed that Mr. Shortt's great advances were two in number, firstly, the simple mode in which he synchronised his slave pendulum, and, secondly, the hanging of the master pendulum in a low pressure.

He took exception to what Mr. Hope-Jones had said about inventors not understanding the principle of the slave. Personally he ventured to think he did understand it. When he read his paper before the Physical Society, Professor Boys was in the Chair, and after the paper had been read Professor Boys had made some very interesting remarks, one of which was that his (Mr. Bartrum's) method of synchronising could have been greatly simplified if he had merely arranged that the error of the slave should be wiped out by a definite chunk, either positive or negative. Mr. Shortt had gone one better than that. By keeping his slave with a losing rate he just wiped out a chunk of error and reversed it in one direction only. That was a wonderfully clever idea.

With regard to the low pressure, however, it had been a great surprise to him to find that the resistance to the pendulum had shown such a decrease as the pressure was lowered. He believed the ordinary orthodox physicist would state that the logarithmic decrement of a pendulum, or the dissipation of energy, depended on the viscosity and that the viscosity was independent of pressure. In fact, a learned Professor had given him the figures which Professor Crookes had found as the result of his experiment of swinging a pendulum in different pressures. If the dissipation at atmospheric pressure was taken at 100, when the pressure was reduced to one ten-thousandth of an atmosphere it only fell to 78, and at one-millionth it was still 14. Mr. Shortt had experimented and had found that when he reduced it merely to one-twentieth he had brought down the dissipation of the energy to something like one-fifth. He hoped that Mr. Shortt would publish those results as they would be most interesting. He noticed that the American Geodetic Survey used pendulums hanging in a low pressure—he presumed in order to keep up the swing for a long time.

With regard to the amplitude of vibration, he had discussed that question in his paper with reference to his own arrangement, which was precisely similar to Mr. Shortt's from that point of view, and he had made some experiments. He had come to the conclusion that in a case like this, where the escapement error was likely to be quite small as compared with the circular error, a small amplitude was indicated. He had adopted one degree on each side. Mr. Hope-Jones said that he had taken 140 minutes.

Mr. Hope-Jones: One degree, 40 minutes.

Mr. Bartrum asked if that meant semi-amplitude or the whole.

MR. HOPE-JONES replied the whole.

MR. BARTRUM said therefore that would be 70 minutes on each side.

MR. HOPE-JONES: Fifty.

MR. BARTRUM asked if Mr. Hope-Jones could give any idea of the variation of that amplitude.

MR. HOPE-JONES said it appeared in Professor Sampson's paper of January 14th, read before the Royal Society of Edinburgh. There were some figures given there of the amplitude. Professor Sampson watched the amplitude of the arc very closely under the microscope, but they were small variations.

MR. BARTRUM, continuing, said he desired to conclude by making some general remarks. With his three clocks Dr. Sampson was now getting such records of time that there were indications he was not measuring time, but measuring conditions—either changes of gravity or changes of the earth's magnetic field, or some other changing conditions. Personally he began to think from Mr. Shortt's final result that the next step would be possibly a time-keeper, independent of gravity, and non-magnetic. It seemed to him that they were coming to that—that the pendulum clock had come to finality, because after all, Mr. Shortt measured time to one part in 8-millions. That meant he could detect a change in gravity of one part in 4-millions. He did not know whether there was any possibility of such change, but it seemed to him there were interesting possibilities when one got to such accurate time-keeping.

THE CHAIRMAN said there was one point he would like to put to the author as a possible limit of the pendulum clock, and that was earth tremors. One got earthquake shocks now and again, and one knew that there were small seismic vibrations. If those should, by any fortunate chance, have a period of two or three seconds, they would, he took it, make an ultimate limit on the accuracy obtainable by pendulum clocks; but there was not the slightest evidence so far. One simply had to say that the evidence was against those seismic vibrations being of such amount as to affect the pendulum.

MR. BARTRUM said that Prof. Sampson had showed him that his three clocks—the Riefler, the Leroy and the Shortt—were at times altering their rate together, as if there was some external effect acting on them all.

FATHER J. P. ROWLAND said, with regard to seismic disturbances, he doubted very much if the vibrations, which whilst varying somewhat in magnitude, were always very small, would be likely to affect the clock, but he had often wondered whether small tiltings of the ground, which certainly indicated changes of level with changes of temperature, atmospheric conditions, and perhaps other things, influenced the rate of a clock. It would be extremely interesting if investigations were made as to how far earth movements might limit the accuracy which could be obtained by pendulum clocks. If an instrument were set up to indicate more definitely earth tiltings rather than vibrations, some correlation might be found between the levels and the rate of the clock which would show connection.

MAJOR C. E. PRINCE said the author had referred to the extraordinary accuracy of astronomical clocks. It was rather interesting to try to discover how much of that accuracy was due to physical perfection and how much was due to perfection of the method. For example, it was obvious that, with a pendulum which was non-expansible and working in a perfect vacuum, any errors would be the errors of the method and not of the pendulum itself. He would have been interested to see the two divisions of the subject separated in order to see how much of the accuracy was due to each of them.

It seemed to be laid down by everybody that the smallest possible interference of the pendulum was desirable, but would it not be more scientifically accurate to impulse as often as possible; that was, to supply energy in far more minute quantities more often? It seemed to him from fundamental considerations that was what ought to be done, but there seemed to be some rule against that which apparently had been arrived at by practice, and which he would like to have explained.

With regard to the question of the accuracy obtained from putting the pendulum in a very low pressure, was that because the pressure was low, or simply because in the containing case the variations of atmospheric pressure from outside were not felt?

MR. R. J. LOW said it appeared from the diagram shown on the wall that the rate was always changing. Had any attempts been made to compare it with magnetic charts over a corresponding period, and also with the gravitational effects of the position of the moon, and the sun, and the tide? Also, were the comparisons taken at exactly the same time every day? He asked this because when he was watching the Synchronome slave clock working, he had noticed that the hit-and-miss governor did not work every time. If one looked into it very carefully one saw that it was undergoing what he might call a rhythmical hunt. It might be the same with the master clock—that if one could analyse its motion carefully enough one would find it was alternately running fast and slow, and that if one got a graph of it it might look something like an ordinary sine curve. When those concerned had compared the clock every day for a week they might have chanced to take all the points above the zero line for one week, and in another week they might have chanced to take them all below the zero line. Had that any bearing on the graph shown on the wall?

With regard to magnetic effects, to his mind it seemed entirely wrong to have a magnetic field anywhere near a swinging pendulum, as this field is never constant, owing to the varying battery voltage and resistance, and also the earth's field. These fields were bound to affect even a metallic pendulum of non-magnetic material, and much more so one of invar, which was magnetic.

THE AUTHOR, in reply to Mr. Low, said the period at which the clocks were compared every day at Edinburgh was either uniform, or else an allowance was made for any differences which might occur through known causes, and things were brought to a uniform time datum for observation. That was mentioned in the paper to which he had referred, which had been read before the Royal Society of Edinburgh on January 14th last. He hoped it was perfectly clear to Mr. Low's mind that no variation of battery in the electric self-winding action or Synchronome remontoire, could possibly affect time keeping. In many systems of electric clocks he was sorry to say the impulse imparted to the pendulum varied as the battery varied. There was nothing whatever of that kind here. He gathered that Mr. Low objected to the presence of an occasionally active electro magnet anywhere near the pendulum. That was one of those refinements to which possibly people would turn their attention now. Having got down to a fresh datum of accuracy one looked forward to the slightest possibilities. It had never occurred to him before that such things could possibly be a source of variation.

Mr. Bartrum had ably put forward the possibilities of the achievement of such great accuracy in time-keeping leading investigators into deeper considerations altogether—as to whether it was quite Time which they were measuring.

The chart on the wall actually did show the variation of gravity. The question had been asked as to whether the moon was affecting that rate. It had been pointed out to him that for the period of nine months the variations in the chart exactly corresponded with the adding or subtracting of the moon's weight to the earth and gravity. Such matters certainly did want looking into. Some of them might be quite laughable when they came before an astronomer, but the fact that such questions were asked showed the present trend of thought.

Major Prince spoke of the impulse being given more often. He quite admitted that, on the basis of pure reason, it might be very well asked what was the difference between giving 30 very small power impulses, one every second, and one larger impulse equal to those 30 added together every half minute? Theoretically it was the same thing, but in practice it was not. They just had to take it from a common sense point of view and consider which could be done with the least variation. He might say that to divide up that impulse of .43 grammes falling a distance of 2 mm. every half minute into 30, the pivot friction might be 50 per cent. of it every time, and that pivot friction would be subject to variation. He thought Major Prince would see his point. It was just a matter of common sense, what one could do best. Prof. Sampson had expressed to him the opinion that very likely it would be better if the impulse was given every minute instead of every half minute.

A vote of thanks to the author for his paper concluded the meeting.

POPULATION, MIGRATION AND EMIGRATION.

The report of the Oversea Settlement Committee for the year ended 31st December, 1923, refers *inter alia* to a memorandum prepared in the Department of the Registrar General. The memorandum, which is printed as an appendix, deals with the factors governing the growth of population in Great Britain and the tendencies which appear to affect that growth. It shows, says the report, that during the past fifty years the annual natural increase of population in Great Britain, notwithstanding a decline in the birth-rate, averaged, before the war, 418,000, or making allowance for the balance of outward over inward migration, about 361,000 a year. It is suggested that there are no sufficient reasons for anticipating any immediate or considerable departure from this amount of natural increase, but that, while the birth-rate may fall still more, there is less scope for a continued decline in the death-rate.

During the past century the population of Great Britian has increased from 14,681,000, its estimated size in 1823, to over 43,000,000, in 1923. This increase was made possible by the discoveries which created modern industry.

As a result of the disturbances which the war has produced, distress has been widely prevalent in this country, and a large part of the population has suffered from unemployment. This situation has raised the question whether Great Britain is or is not over-populated. This is a problem of extreme complexity. Though closely related with the main subject of this report, viz., migration, it covers a far wider field, and raises many issues upon which the Oversea Settlement Committee are not in a position to express an opinion. They therefore confine themselves to an enumeration of the following factors in the problem, which are directly related to migration, viz.:—

(1) There has been a gradual decline in the birth-rate over the last fifty years, but

(2) the effect of this decline on the annual increment has been offset:—

  (a) by the decline in the death-rate, and

  (b) by the geometrical effect upon numbers of any given rate of increase, but

(3) the great diminution in child mortality, which has been largely responsible for the decline in the general death-rate, cannot be expected to have so marked an influence in the future.

On the other hand, a continuous fall in the birth-rate is impossible to predict, since it may be checked by economic recovery.

(4) Having regard to the foregoing, there is no ground for anticipating a rapid reduction of the annual natural increment of something over 400,000, which has persisted since 1870. (The last two years, mid 1921 to mid 1923, during which the natural increase averaged 372,000, may be regarded as abnormal, owing to the exceptional industrial conditions).

(5) The only other important counterbalancing factor is migration. The average annual deduction to be made on this account for the ten years before the war, as shown by the figures for net outward balance of passenger movement to all countries, was 178,000. (This figure, however, includes Ireland. It was based up to 1912 upon the total passenger movement, and after that date was restricted to persons permanently changing their domicile.) The total net migration for the last two years was :—

1922	106,000
1923	198,000

It is thus apparent that migration has not counter-balanced the net natural increase (*i.e.*, balance of births over deaths) of the population.

(6) In the light of these figures and tendencies, it is at least safe to assert that there is no prospect of migration reducing the numbers of the population of Great Britain in a manner injurious to prosperity.

INDUSTRIAL DEVELOPMENT IN CHINA

In his report on the industrial and economic situation of China, the Commercial Secretary to H. M. Legation, Shanghai, points out that no very striking developments in the form of new industrial enterprises in China occurred during the year under review, progress being naturally hampered by the absence of security which continues to discourage the investment of capital elsewhere than in the main Treaty ports. In certain directions, however, notably in the case of flour mills an match factories, the industry continues to grow,and the native products are competing successfully with the imported article. This is especially the case as regards matches, and the Japanese manufacturers who formerly did the bulk of this business are rapidly being driven out of the market. Another industry which is growing in importance is sugar refining, factories for the manufacture of beet sugar having been established in Manchuria, and another company is at present putting up a large refining plant in Shanghai. The establishment of several new cement factories has taken place during the past three years, one of the largest of these being situated n the neighbourhood of Shanghai and another near Liaoyang in Manchuria. Soapmaking, tanning, knitting factories, canneries, paper mills and carpet factories are other industries in which native companies are engaging in increasing numbers. One may safely say that the industrialization of China on modern lines is proceeding steadily in spite of the obstacles created by the absence of any ordered government in that country, and that if conditions in this respect showed any substantial evidence of improvement the example already set by Shanghai and other ports which enjoy the security afforded by foreign settlements or concessions would soon be followed in every part of the country.

GENERAL NOTE.

Conference on Science and Labour.—The programme of the Conference on Science and Labour to be held at the British Empire Exhibition on May 30th and 31st, has been published. The Conference, which has been arranged by the British Science Guild in co-operation with the National Joint Council of the Trades' Union Congress and the Labour Party, will be opened by the Prime Minister. There will be five sessions, the subjects of discussion being :—(1) The Place of Science in Government; (2) Scientific Research in Relation to Industry; (3) Co-operation of Science and Labour in Production; (4) Science and the Human Factor; (5) Science in Educational Organization. Sir Richard Gregory will preside and Mr. Sidney Webb, President of the Board of Trade, will open the discussion on Science in Government, and Sir Richard Glazebrook and Major Church, M.P., will speak. At the second session Lord Askwith will preside, and the chief speakers will be Mr. Hugo Hirst, Sir Oliver Lodge, Sir Daniel Hall and Mr. A. P. M. Fleming. Mr. C. T. Cramp will preside at the discussion on Science and Production, and the speakers are Lord Ashfield, Sir Hugh Bell and Mr. W. Straker. The fourth meeting will deal with Health and Psychology. Miss Margaret Bondfield, M.P., will preside, and the speakers include Sir Arthur Newsholme, Dr. C. S. Myers, Dr. Cyril Burt and Miss May Smith. At the final session Mr. Arthur Greenwood, M.P., will preside, and the discussion on Science in Educational Organisation will be opened by Mr. R. H. Tawney, who will be followed by Sir Thomas Holland and Dr. R. P. Scott. Copies of the programme and tickets of admission may be obtained by application to the Conference Secretary, 15, Gower Street, W.C. 1.

MEETINGS OF THE SOCIETY.

Ordinary Meeting.

Wednesday :—

May 28 (at 4.30 p.m.)—Mrs. Arthur McGrath (Rosita Forbes), "The Position of the Arabs in Art and Literature." Lord Askwith, K.C.B., K.C., D.C.L., Chairman of the Council, will preside.

Indian Section.

Monday June 30, at 4.30 o'clock.—J. C. French, I.C.S. "The Art of the Pāl Empire in Bengal." The Right Hon. the Earl of Ronaldshay, G.C.S.I., G.C.I.E., will preside.

Dominions and Colonies Section.

Tuesday, May 27, at 4.30 o'clock.—C. Gilbert Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "A Sketch of the Geology and Mineral Resources of Cyprus." Dr. J. W. Evans, C.B.E., F.R.S., President of the Geological Society, will preside.

Monday, June 2, at 5 o'clock.—The Rt. Hon. Sir Frederick Lugard, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member, Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates." The Rt. Hon. Viscount Milner, K.G., G.C.B., G.C.M.G., will preside.

Monday, June 16, at 4.30 o'clock.—C. V. Corless, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

Monday, May 26 .. Victoria Institute, Central Buildings, Westminster, S.W., 4.30 p.m. Colonel H. Biddulph, "The True Harmony of Man."
University Extension Lecture, Gresham College, Basinghall Street, E.C., 7.30 p.m. Mr. A. Compton-Rickett, "Personal Forces in Modern Literature: Lecture V.—Walter De La Mare."
University of London, University College, Gower Street, W.C., 5 p.m. Prof. G. D. Hicks, "Kant's Theory of Sublimity and Beauty." (Lecture III.)
At King's College, Strand, W.C., 5.30 p.m. Mr. A. J. Toynbee, "The Saviour King in Greek Tradition."

Tuesday, May 27 .. Royal Institution, Albemarle Street, W., 5.15 p.m. Major M. S. Tucker, "Acoustical Problems." (Lecture II.)
Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 4 p.m. Hon. Sir Joseph Nunan, "India and the Colonisation of British Guiana."
Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. F. L. Emmanuel, "Etching."
University of London, at King's College, Strand, W.C., 5.30 p.m. Prof. E. Prestage, "The Diplomatic Relations between Portugal and England from 1640 to 1668."
At the Imperial College, Royal School of Mines, South Kensington, S.W., 5.15 p.m. Dr. W. G. Miller, "The Pre-Cambrian, with special reference to that of Ontario." (Lecture III.)
Master Glass-Painters, British Society of, University College, Gower Street, W.C., 3 p.m. (1) Dr. Ethel Mellor, "The Decay of Window Glass from the Point of View of Lichenous Growths." (2) Mr. Nöel Heaton, "The Decay of Mediæval Stained Glass." (3) Prof. W. E. S. Turner, "The Weathering and Decay of Glass."
Royal Dublin Society, Leinster House, Dublin, 4.15 p.m. (1) E. R. G. Atkins, "Notes on the Filtration and other Errors in the Determination of the Hydrogen Ion Concentration of the Soil." (2) J. L. McWhinney, "The Soil Fauna of a Permanent Pasture." (Communicated by Prof. Wilson.)

Wednesday, May 28 . Microscopical Society, 20, Hanover Square, W., 7 p.m. (1) Mr. J. E. Barnard, Lecture Demonstration on "Technical Microscopy." 8.15 p.m. (2) Mr. E. Sheldon Leicester, "The Use of the Microscope in the Examination of Paper." (3) Mr. K. MacLennan, "The Microscopy of Soaps."
University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. S. Riccobono, "Roman Law and Modern Law." (Lecture I.)
3 p.m. Prof. E. G. Gardner, "Problems of the 'Inferno' of Dante." (Lecture II.)
At the Lodon School of Economics, Clare Market, W.C., 5.30 p.m. Prof. A. J. Sargent, "The Trade of the Empire."

Thursday, May 29 .. Aeronautical Society, at the Royal Society of Arts, John Street, Adelphi, W.C., 8.30 p.m. (Wilbur Wright Memorial Lecture.) Colonel H. T. Tizard, "Fuel Economy in Flight."
Royal Society, Burlington House, Piccadilly, W., 4.30 p.m. (Croonian Lecture). Prof. D. M. S. Watson, "The Structure, Evolution and Origin of the Amphibia.
Antiquaries' Society, Burlington House, Piccadilly, W., 8.30 p.m.
Royal Institution, Albemarle Street, W., 5.15 p.m. Prof. C. G. Seligman, "Divine Kings and Rainmakers of the Sudan."
University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. S. Riccobono, "Roman Law and Modern Law." (Lecture II.)
5.30 p.m. Prof. R. W. Chambers, "Ruskin on Byron."
At King's College, Strand, W.C., 5.30 p.m. Prof. A. J. Toynbee, "Outlines of Byzantine, Near Eastern and Modern Greek History (378—1841 A.D.)." (Lecture VI.)
Transport, Institute of, Grand Hotel, Bristol, 10 a.m. Annual Congress. (1) Mr. D. Ross-Johnson, "The Port of Bristol, Past and Present." (2) Colonel E. S. Sinnott, "The Problem of Road Surfaces with regard to Mechanical Transport."

Friday, May 30 .. Mechanical Engineers, Institution of, (South Wales Section), University College, Swansea. Summer Meeting.
Geologists' Association, University College, Gower Street, W.C., 7.30 p.m.
Sanitary Institute, Royal Spa Rooms, Harrogate, 4.15 p.m. Discussion on "Public Health Services: Are they worth the money expended?"
Royal Institution, Albemarle Street, W., 9 p.m. M. Lucien Bull, "Recent Developments in High Speed Cinematography."
University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. H. Pirenne, "Les Périodes de liberté et de réglementation dans l'histoire économique." (Lecture I.)
5.30 p.m. Miss Marjory S. West, "The Old Testament." (Lecture III.)
Shakespeare Association, King's College, Strand, W.C., 5.30 p.m. Mr. C. Rhodes, "The Acting of Shakespeare in the Provinces."
Transport, Institute of, Grand Hotel, Bristol, 10 a.m. Congress continued. (1) Mr. H. R. Griffiths. "Freight Train Formations." (2) Colonel W. A. Bristow, "The Next Five Years of Aerial Transport."

Saturday, May 31 .. Royal Institution, Albemarle Street, W., 3 p.m. Mr. C. Nabokoff, "Shakespeare in Russia."

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FRIDAY, MAY 30, 1924.

All communications for the Society should be addressed to the Secretary, John St., Adelphi, W.C.2.

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NOTICES.

NEXT WEEK.

MONDAY, JUNE 2nd, at 5 p.m. (Dominions and Colonies Section.) THE RT. HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member, Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates." THE RT. HON. VISCOUNT MILNER, K.G., G.C.B., G.C.M.G., will preside.

Further particulars of the Society's meetings will be found at the end of this number.

SOCIETY'S ALBERT MEDAL.

The Albert Medal of the Society for the current year has been awarded by the Council, with the approval of HIS ROYAL HIGHNESS THE PRESIDENT, to HIS ROYAL HIGHNESS EDWARD, PRINCE OF WALES, K. G., "in recognition of services rendered to Arts, Manufactures and Commerce as President of the British Empire Exhibition, and by his visits to the Dominions and India."

TWENTY-SECOND ORDINARY MEETING.

WEDNESDAY, MAY 21st, 1924; SIR HERBERT JACKSON, K.B.E., F.R.S., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Allen, John Scott, Lismore, Ireland.
Blake, Captain Sir H. Acton, K.C.M.G.. K.C.V.O., London.
Cawston, Frederick Gordon, M.D., B.Ch., M.R.C.S., L.R.C.P., Durban, South Africa.
Daniell, Major John Alan Le Norreys, Sudbury, Suffolk.
Longman, Charles James, M.A., J.P., London.
Mattocks, Captain, F.S., R.E., Quetta, India.
Rummell, G. Albert, Cincinnati, Ohio, U.S.A.

The following candidates were duly elected Fellows of the Society:—

Airth, George Rennie, London.
Broemel, Percy Rudolph, London.
Graham, Edward Alfred, Beckenham, Kent.
Webber, Henry O'Kelly, Johannesburg, South Africa.
Wreford, Ernest Henry, East St. Kilda, Australia.

The seventh Trueman Wood Lecture on "The Outlook in Chemistry" was delivered by SIR WILLIAM J. POPE, K.B.E., D.Sc., LL.D., F.R.S., Professor of Chemistry in the University of Cambridge.

The lecture will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

NINETEENTH ORDINARY MEETING.

WEDNESDAY, 30TH APRIL, 1924.

MR. HARRY GOSLING, C.H., M.P. (Minister of Transport), in the Chair.

THE CHAIRMAN, in introducing the lecturer, said that one thing had struck him, namely, that, whenever there was a discussion about road improvements, it was surprising the number of people who came to him in the position which he was at present enjoying and said "Now, whatever you do, be careful not to destroy anything which is old and beautiful, and be sure you do not attempt, in making your improvements, to interfere with those things which have been regarded for centuries as almost sacred." On the other hand, there had to be taken into consideration the question of the losses to trade and commerce through the absence of facilities for traffic. Being one of those who believed that there could not be good business unless there was good transport, he felt he had now connected himself with one of the most serious problems of the day. He was happy in the thought, however, that he would not be troubled with the question of interference with any beautiful structures in the area with which Sir Henry was going to deal that night! He remembered that not very long ago a new dock had been opened in that neighbourhood, and some very distinguished visitors were going down there to perform the opening ceremony. The authorities had had to

consider how to get them there; there was not a road fit to take them down, and eventually, in order to avoid drawing the attention of those distinguished visitors to the poverty of that neighbourhood in good means of road transit, they had had to be carried on the old highway—the river.

Then there was the difficulty of finance. Another set of people came along and said "What about the money? Who is going to pay for it." He had been driven to the conclusion—and he asked his hearers not to think it was Socialism—that our great main roads would have to be regarded from a national standpoint, more particularly when he remembered how many of the local authorities, in whose districts better transit facilities were needed, could not find the necessary money to do the work. In that connection he was not speaking merely of London but of great agricultural districts. Therefore, much as he was opposed to some forms of Socialism, he believed that one of the great social reforms in this country was the improvement of main roads, and he thought all would have to put their hands in their pockets equally to find the necessary money. It was not only the district in question, but the whole of London which would benefit if improvements such as Sir Henry was going to elaborate that night could be brought about. Anybody who had been connected with a great port must know that a port was not complete until suitable avenues had been made which conveyed goods to and from the port. He was hoping that some business body would try to find out what was lost by not having such roads. He had often wondered himself how much bad roads cost the country in the way of money, to say nothing of the delay.

It used to be said at one time that all roads led to London. Personally he would say that all roads led from Maybury. Sir Henry was an enthusiast and an authority on the subject, and he would now ask him to tell the audience everything about the proposed new road.

The paper read was:—

THE VICTORIA DOCK DISTRICT AND ITS ROADS.

By Sir Henry Maybury, K.C.M.G., C.B., M.Inst.C.E., Director of Roads, Ministry of Transport.

Among Londoners it is customary to speak with bated breath of the "Square Mile," signifying thereby, of course, the City of London—that Thames-side hillock which is so densely clad with buildings that we are apt to lose sight of the river which forms the real foundation of London's wealth—the river Thames with its docks, wharves and grimy foreshore.

Let me, therefore, take you to-night to another riverside "square mile" which is not the City, but which is fundamentally almost equally important—I mean the dock district lying immediately east of the River Lea and known for the greater part as Silvertown.

End to end along the north edge of this district lie the Victoria Dock and the Royal Albert Dock. Immediately south of the latter is the King George V. Dock, capable of taking vessels of the Olympic Class, while north of the Albert Dock lies a site for a still larger dock.

You will see that we have here the most imposing cluster of docks that London can shew, while the Thames frontage of Silvertown is occupied almost exclusively by large works and factories, all giving rise to busy traffic, heavy both in volume and weight. Add to this the flow of vehicles to and from the Woolwich Ferry—that invaluable link between Essex and Kent—and you will appreciate the importance of road-communications in this area. Nor has the climax yet been reached, for the new dock to which I have alluded has not yet been begun, and land still remains vacant for future industrial development.

By one of the humorous anomalies of metropolitan government Silvertown forms no part of the administrative County of London, but is included in the County Borough of West Ham, which has suffered from the malady of unchecked distension. Its population in 1861 was 38,331 and in 1921 eight times greater—300,860. West Ham has never possessed the resources or influence effectively to control the development of Silvertown, much less the amazing contortions of the River Lea which impose such difficulties on bridge-builders.

The neighbourhood is one of those which, as Dickens complained in 1854, "the legislature leaves to come into existence, just as it may happen; overthrowing the trees, blotting out the face of the country, huddling together labyrinths of odious little streets of vilely constructed houses; heaping ugliness upon ugliness, inconvenience upon inconvenience, dirt upon dirt, and contagion upon contagion."

The result at Silvertown provides town-planners with conspicuous examples of what to avoid. For our ancestors' want of foresight the penalty has long been accumulating, and payment is now overdue. It is my task to-night to deal with one phase only of the arrears—road communications

—to show you what disabilities the district now labours under, and what means of relief might be applied if London as a whole would put its shoulder to the wheel, as I am fully convinced it will do.

Before dealing with the present plight of this area, it will be interesting to cast a glance backwards and observe some of the stages through which its development has passed, in days when its future industrial importance was little suspected.

From the earliest times until shortly after 1800, the crossing of the River Lea at Canning Town was by a ferry connecting with a rough track leading to Barking, whence a narrow circuitous road skirted the northern edge of the marshes to Tilbury. Across these marshes ran a few cattle tracks, some of which led down into the riverside flats which have since become the Silvertown and North Woolwich Dock areas. The whole tract of country crossed by the Barking Road was so low-lying and unhealthy as to support few living beings save the sheep, horses and cattle which grazed there. The depressing dampness and fogs seem to have reacted on the health and characters of the scanty human residents, for in 1700 one of the historians of the time, records that the people had a peculiar character derived from their unwholesome environment. He stigmatized them as "persons of so abject and sordid a temper that they seem almost to have undergone Nebuchadnezzar's fate, and by conversing continually with the beasts to have learned their manners."

These marsh lands were the happy hunting ground of horse thieves and have a legendary association with Dick Turpin, who used the Hackney Marshes, a little farther north, as his headquarters and refuge, being conveniently close to the roads through Epping Forest.

Extensive schemes for dyking and draining these Thames-side flats were undertaken at the end of the 16th century, the work being usually left to Dutch immigrants, who were acknowledged experts in the science of land-reclamation.

To the English of that day the introduction of foreign labour was as unpalatable as the innovation of systematically draining and dyking the marshes. Popular feeling was expressed in a ballad of the time from which the following is an extract:—

"Our smaller rivers are now dryland
Our eels are turned to serpents there,
And if old Father Thames play not the man
Then farewell to all good English beer.
Why should we stay then and perish with thirst,
To the New World in the Moon then away let us go,
For if the Dutch Colony get thither first,
'Tis a thousand to one that they'll drain that too."

A slide has been prepared shewing the area as it was in 1807 when the district was roused from its sleep of many centuries duration by the commencement of the Barking Road—the East India Dock Company having decided to build a new highway to facilitate the transport of goods from Essex to the Company's docks, and also to provide a shorter route to the metropolis from Barking, where fish intended for London was landed.

A cast-iron toll-bridge across the Lea was built and opened in 1810—the total width of the bridge between parapets being only 28 feet. There were four narrow side-spans and a wider central opening for river traffic.

The road did not at first realize the promoters' expectations; being built for the most part on marshy ground it became so spongy that heavy traffic avoided it. Some 15 or 20 years elapsed before it became thoroughly serviceable.

Several years passed before the man at the toll bridge took enough money to pay his own wages; frequently owing to the poverty of the inhabitants he had to accept a pocket knife or some similar article in default of the regulation half-penny which the wayfarer was unable to produce.

This original iron bridge was designed by Mr. James Walker, then president of the Institution of Civil Engineers. It was composed of cast iron semi-circular ribbed arches with supporting columns of the same material. Later on the original approaches, which were very steep, were modified and easier gradients formed. The toll was abolished, I believe, in 1871.

In 1811 a horse ferry across the Thames was established between Old Charlton on the South and the spot which was to become North Woolwich. Advantage was thus taken of the new Barking Road and a useful means of transit provided for Kent farmers taking their cattle to the Romford market. A road connecting the ferry with the Barking Road was built following existing

tracks across the marshes. It is still called Prince Regent's Lane, and was widened about 20 years ago to its present width.

The Manor Road, which you see to the right of Prince Regent's Lane, and also connected with a ferry to the Kentish Shore, is a very much older road and appears on maps as early as 1720. No doubt it existed long before that date.

The Barking coach ran twice daily from the Bull Inn, Barking, to the Bank, the return fare being 3/- inside and 2/- outside. Seats were booked overnight. The guard used to blow his horn when on the Iron Bridge at 12 o'clock noon, and so announce the hour to the scattered houses round. As late as 1845 there were only 6 houses between Plaistow and the Iron Bridge. It was at about this time that the Ripple Road from Rippleside to Dagenham was constructed to give better communication with Tilbury.

In 1847 a railway was built to the ferry in North Woolwich, and the promoters also formed a syndicate to buy the land lying between the Barking Road and the Thames. Houses were built in North Woolwich, but owing to the unhealthiness of the marshes and despite cheap season tickets, the venture was a doubtful success. To encourage the population a garden was laid out there, for bowling, dancing and other distractions. These grounds were acquired by the public in 1890, and are now administered by the London County Council as the "Royal Victoria Gardens." At about the middle of the 19th century, there also came into existence the line of road from Canning Town to North Woolwich, which passes by the White Gates, and is now known as the Dock and North Woolwich Road.

The most important stage in the growth of this neighbourhood occurred in the latter half of the 19th century; the advent of steam and of larger iron ships called for more spacious dock accommodation, and in 1855 the Victoria Dock Company opened the Victoria Dock, which was immediately an enormous success, and in 1860 attracted 854,000 tons of shipping.

About this time the loop road, which passes Connaught Road Station, was built, and this concludes the record of any important highway development in the district, although the area of the docks has since been more than doubled, and the tonnage of shipping has risen in the phenomenal degree indicated in the subjoined table, for which I am indebted to the Port of London Authority:—

Net Register Tonnage of Loaded vessels from Foreign and Colonial Ports entering the Royal Victoria & Albert and King George V. Docks to discharge.

Year.	Net Register Tonnage.
1865	327,643
1866	330,286
1867	361,527
1891	1,497,551
1892	1,536,551
1893	1,639,175
1921	2,426,918
1922	3,078,770
1923	4,148,443

N.B.—The Royal Victoria Dock was opened in November, 1855, the Royal Albert Dock in July, 1880, the King George V. Dock in July, 1921.

In 1880 the London and St. Katherine Dock Company, which had absorbed the Victoria Dock Company, opened the Royal Albert Dock. At that time the largest vessel coming regularly to the Port of London was the Queen, of the National Line, with a tonnage of 4,457.

In 1870 the Beckton Road was built by the Gas Light and Coke Company, and the Southern portion still remains their private road.

In 1887 a steam tug colliding with the Iron Bridge across the Lea, made it unsafe, and eventually the London County Council decided to build a new structure, which was opened in 1897—and is still in use. It has a total width between parapets of 55′ 0″, and was designed by Sir Alexander Binnie. It is composed of 12 mild steel ribs, having a span of 150′. The approaches to this bridge are a constant source of delay, especially to horse-drawn traffic, for in addition to the difficulty of the 1 in 29 gradient on the Eastern approach, there is a sharp curve to be negotiated, paved with granite setts on which horses are constantly in trouble. So frequent is the interruption to traffic from this cause that special appliances are held in readiness to assist horses out of their difficulties.

This bridge carries the major portion of the traffic between London and the Victoria, Albert and King George V. Docks as well as the numerous factories in the Silvertown, Canning Town, East Ham and Barking districts, and a considerable portion of the road traffic to the Tilbury Docks; it also bears agricultural and market garden traffic between South Essex and London.

To bring our history up to date, there remain to be recorded the birth of new industries, the concurrent growth of population and traffic, the opening of the King George V. Dock in 1921—in fine a stir of activity in every sphere except that of civic design and roadmaking, which have always been the two crying needs of Silvertown. One saving clause may be inserted; in 1921, the Ministry of Transport undertook, with the aid of various local authorities, the construction of the East Ham and Barking Bye-Pass which, when completed, will provide a new eastern outlet to this dock district, and will afford spacious means of access to a wide stretch of Thames-side land yet to be developed, and, let us hope, developed with due regard to the painful lessons of the past.

I refer with some pleasure to this new arterial road, since it forms the first chapter in what I trust will be a comprehensive volume of riverside improvement.

The foregoing recital will serve to shew you how an all-important dock district has grown up without any care or foresight being bestowed upon the vital factor of road access—whether for goods entering and leaving the docks or for the army of workers engaged in handling them.

However, for good or evil, there is the legacy that London inherits. Let us look the gift-horse in the mouth and examine the principal blemishes.

First and foremost, approaching from the London end is the "Iron Bridge," which I have already described. It is the funnel through which are poured all the streams of traffic bound for riverside and dock destinations from Poplar to Tilbury—sixteen miles as the crow flies, and including about 20 miles of river frontage, rich in potentialities. This Iron Bridge of which I have mentioned the limitations and inconvenience, was the subject of a traffic census taken in December, 1922, when it was found that the roadway was carrying 32,103 tons of traffic in 24 hours, exclusive of pedestrians.

Mechanically propelled vehicles represented 80 per cent. of this total—a somewhat low proportion, showing what a considerable part is still played in the dock district by horse-drawn vehicles.

Judging by a previous census taken 9 years earlier, the increase of traffic in that period may be computed at about 18 per cent.

Proceeding eastwards from the Iron Bridge, we encounter at a distance of 200 yards two obstructive features which continually impede the flow of traffic, viz., first the bridge over the railway at Canning Town where a girder projects up into the centre of the roadway, and secondly the right-angled junction of the Victoria Dock Road, the traffic from which surges into the Barking Road, at this already congested and obstructed point on a rather trying up-grade. Confusion and delay are consequently unending.

We now turn south down the Victoria Dock Road, which has a carriageway only 21 feet wide where it joins the Barking Road, and where heavy traffic has to swing out widely in order to clear the right-angled corner. This narrow width of 21 feet is maintained for a distance of nearly half-a-mile, when we arrive at the sadly notorious level crossing known as the White Gates, a most prolific source of delay—since the entire rail traffic to and from this dock area passes between these gates. On the adjoining roads the line of waiting vehicles often extends over 300 yards towards Canning Town; as many as 130 vehicles have been counted in this queue.

The following figures supplied by the Borough Engineer of West Ham are very informative, both as to volume of traffic and the hindrance to which it is subject. They do not by any means shew the total road traffic to and from the docks, for much of the traffic takes the Northern loop road towards the Connaught Road Station, and so avoids both the White Gates Level Crossing and the further delay at the swing bridge across the entrance to the Victoria Dock, of which more anon.

In 1904 the average number of vehicles passing the White Gates in 24 hours was 2,173, in 1913 it was 2,496, and in 1922 it was 2,852.

The gates had to be closed for the passage of trains for an average, in

1904 of 10 hours, 36 minutes, in 24 hours;
in 1913, of 9 hours 39 minutes;
and in 1922, of 9 hours 6 minutes.

It will thus be seen that the road is completely blocked to traffic for an average of 40 per cent. of the 24 hours, but at the busiest periods of the day the gates are closed for 47 minutes in the hour.

Just short of the White Gates level crossing the Victoria Dock Road divides: one branch becomes the Dock and North

Woolwich Roads leading southwards, while the other branch (Victoria Dock and Connaught Roads) skirts the northern side of the docks; both branches eventually re-unite in the Albert Road leading to the ferry. All these roads have a carriageway which varies in width from 20 feet to 26 feet—rarely more—and generally speaking only one footway will be found, about 7 feet wide.

The chief and by far the most notable inconvenience to traffic is caused by the level crossings and swing bridges which are a conspicuous feature of both branch roads. On the Northern branch in the vicinity of Connaught Road Station, immediately following a right-angled bend in the road, are in close succession (1) a level crossing over the Beckton Branch Railway, (2) the level crossing over Gallions Branch Railway; (3) the level crossing over the goods railway serving the northern side of the docks (each crossing having its own set of gates), (4) the swing bridge over the passage connecting the Victoria and Albert Docks, and (5) the level crossing over the goods railway serving the Southern side of the Albert and the Northern side of the King George V. Docks. Each of these obstructions may in turn hold up a vehicle wishing to pass, and delays of as much as ¾ of an hour are fairly common at the busiest times of the day. When the north-bound traffic seeks to make its way past the accumulated south-bound vehicles the confusion and congestion are almost indescribable, particularly at the corners, and opposite the large cold storage and other warehouses.

On the southern branch the obstructions are equally severe. However keen competition may be elsewhere, no buses venture down these routes.

A short distance after passing that formidable barrier, the White Gates, which I have already described, you reach the swing bridge across the lock entrance connecting the west end of the Victoria Dock with the Thames. This is a single track bridge and its 9ft. carriageway also forms the track of the goods railway serving the south side of the Victoria Dock. While railway trucks are passing, which they do many times a day, vehicular traffic is necessarily obstructed—and as many as 164 vehicles have been counted waiting to pass this bridge. There is another obstructive level crossing near Silvertown Station.

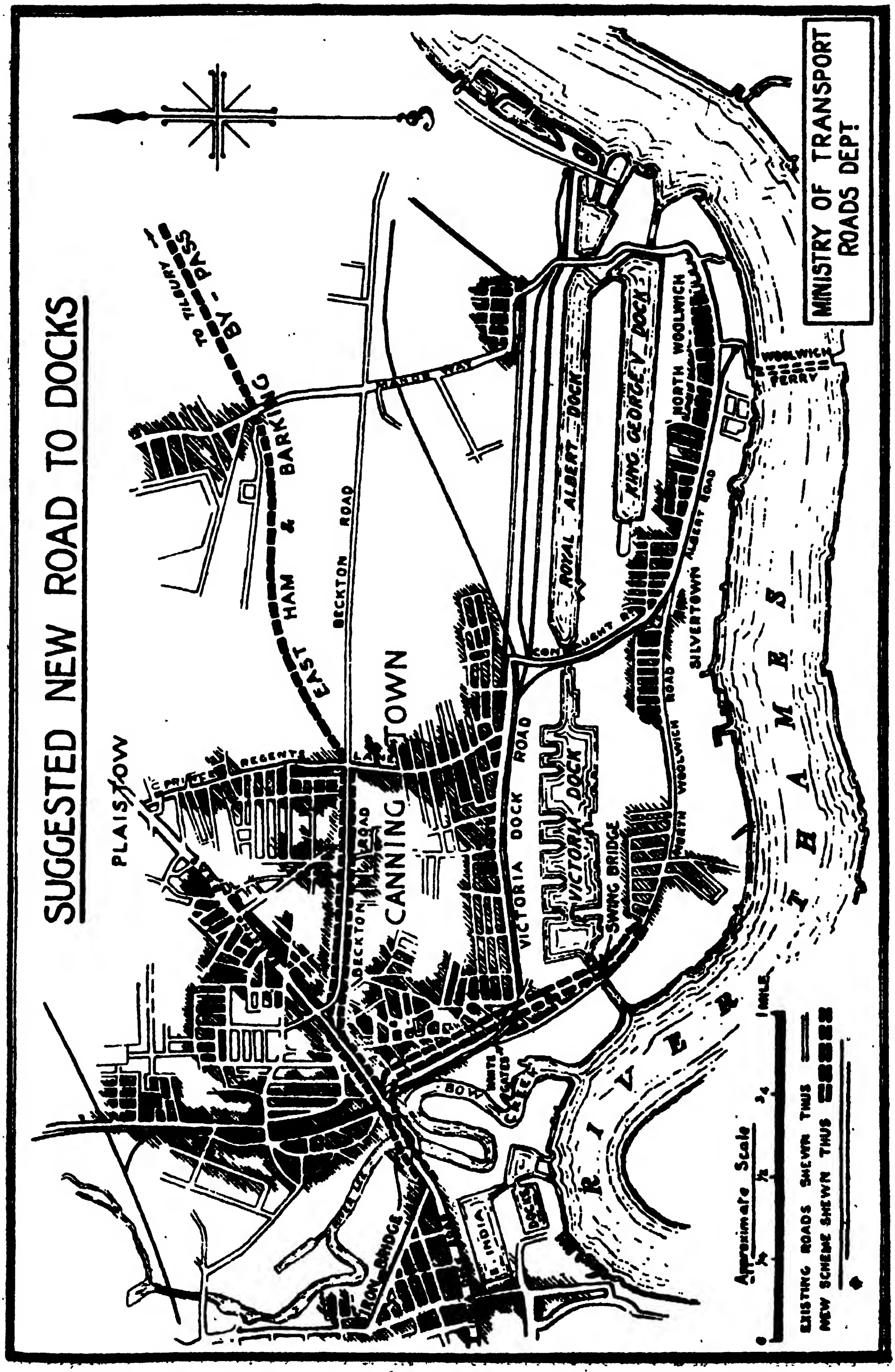
The effect of these adverse conditions at the Iron Bridge, the Canning Town Railway Bridge, the junction with the Victoria Dock Road, the swing bridges, the White Gates and the other level crossings, becomes cumulative, since all these obstructions are so close together that when one is removed the flood of dammed-up traffic is immediately added to the block already forming against the next barrier. The delays attendant upon the level crossings and swing bridges not only affect vehicular traffic, but they are a constant source of bad time-keeping by factory employees, and the inadequate road connections and approaches militate seriously against further commercial enterprise in the district.

So large a proportion of London's vehicular traffic originates or terminates at the Docks that we may say without exaggeration that delays here produce a retardation of movement throughout the entire Metropolitan area—a fact which strengthens my plea for contributions towards the cost of the improvement from the widest possible region.

Through the courtesy of a well-known haulage contractor, I have recently had an accurate log kept for several entire days on certain lorries performing their usual journeys in and around the Silvertown area—the longest individual journey being approximately 4½ miles. Tabulating these records, the deduction can be made that approximately 35 per cent. of the time occupied by the journeys is absorbed in the delays caused directly and indirectly by the obstructions I have enumerated, such as swing bridges, level crossings, etc.

So much for the growth of Silvertown and the woeful tangle in which it now finds itself.

I pass to the pleasanter subject of possible remedies, though it is well to remark at the outset that no cheap cure can be prescribed. High though its cost may be, however, I am satisfied that the vital interests of the Imperial Capital demand the immediate inception of this scheme, the urgency of which was recognised as far back as 1912, when the Road Board (since absorbed in the Ministry of Transport) offered to contribute £100,000 towards the outlay involved. I fear by the way, that £100,000, which sounded a large sum in the frugal days of 1912, will not go far towards the cost of the scheme which I am about to describe, and which will be illustrated by lantern slides photographed


SUGGESTED NEW ROAD TO DOCKS
MINISTRY OF TRANSPORT
ROADS DEPT
TO TILBURY
BY-PASS
BARKING
EAST HAM &
BECKTON ROAD
PLAISTOW
CANNING TOWN
VICTORIA DOCK ROAD
ROYAL ALBERT DOCK
KING GEORGE V DOCK
VICTORIA DOCK
SWING BRIDGE
NORTH WOOLWICH
SILVERTOWN
ALBERT ROAD
NORTH WOOLWICH ROAD
WOOLWICH FERRY
RIVER THAMES
BOW CREEK
E. INDIA DOCKS
IRON BRIDGE
Approximate Scale
EXISTING ROADS SHEWN THUS
NEW SCHEME SHEWN THUS

from maps and a model prepared for the purpose of simplifying the study of the problem.

We will start in the East India Dock Road, on the London side of the River Lea. This road, as the result of recent widenings measures now 50 feet in width, between the kerbs, but narrows down, unfortunately, at the corner of Leamouth Road, where the curved approach to the iron bridge begins. Let us begin by widening the East India Dock Road from Leamouth Road eastwards to a dimension of 100 feet, remove the old tortuous iron bridge and build a new structure 100 feet wide in nearly direct alignment with the Barking Road on the other side of the Lea. We ought then to widen the Barking Road to the same dimension of 100 feet up to the point where it will intersect with a remodelled and re-aligned Beckton Road. This improvement of the Barking Road will obviously be a costly matter, involving demolition of property down one side at least, the re-building of Canning Town Station and the widening of the railway bridge there.

Beckton Road, which as I have just said, will need to be re-modelled and re-aligned, will possess great importance in the near future, as forming the western extension of the East Ham and Barking By-Pass now nearing completion. Although termed a by-pass, it will be in fact the direct London-Tilbury Road, and enable drivers to avoid East Ham, Barking and other congested areas.

It will therefore be necessary to widen Beckton Road to the same dimension as the East Ham By-Pass, namely, 100 feet, and to straighten out its western end so as to give it a direct discharge into the Barking Road, instead of bending unnecessarily northwards as it does now.

The works just described in connection with the East India Dock Road, the Iron Bridge, the Barking Road and the Beckton Road, will afford a clear channel for traffic from London eastwards, and it now remains for me to explain what can be done to enable traffic to penetrate southwards through the tangle of level crossings and swing bridges, so as to reach Silvertown and destinations in the dock district generally.

To follow this part of the scheme we must return to the new eastern approach of the Iron Bridge. You will remember that the narrow Victoria Dock Road here joins the Barking Road at right angles. Instead of adopting this line, let us build a boldly curved road 80ft. wide, springing from a point somewhat further west. Instead of dipping down to the present street level, we will follow an ascending course and place our new road on a viaduct set some 200ft. east of the present Victoria Dock Road.

The existing maze of cross roads will pass underneath the viaduct, as will also the railway lines which now inflict such incalculable delays upon road traffic at the White Gates. Our new viaduct will also pass at a high level over the western outlet from the Victoria Docks, where, instead of the present single track bridge, a new swing bridge 60ft. wide would be provided for vehicles and pedestrians. From this point southwards the new viaduct would descend by an easy gradient to join the existing North Woolwich Road, near the intersection of Cranbrook Road.

At one point on our new viaduct a spur road will have to be constructed to enable traffic from the Tidal Basin Road to ascend to the higher level of the viaduct.

Those employers and workers whose daily routine brings them into perpetual, irritating contact with the present traffic obstructions, will best appreciate what invaluable relief would be afforded by the creation of this high level road which would, in my judgment, amply justify the cost of its construction and the incidental disturbance of trade and property.

Obviously, that disturbance, although temporary in its nature, will be fairly extensive. Measuring the length of the portions of the East India Dock Road and the Barking Road which have to be transformed (including the new bridge), we reach a dimension of 1,000 yards. The widening and extension of the Beckton Road accounts for another 1,600 yards, while the new viaduct road measures about 2,000 yards in length, including the swing bridge.

The widening of streets and the clearance of property required for the new roads will entail the demolition of nearly 700 houses, but few of these buildings are of such a character as to call for an apology for their removal. Indeed, I suspect that housing reformers will welcome the ventilation of this congested area by the piercing of a new road. In any event, there is no making of omelettes without the breaking of eggs, and in this

case we have the consolation that the substituted accommodation built for displaced residents will certainly show great advantages over the present tenements. I should hope that the re-housing might be carried out, with the concurrence of the London County Council, on the large Estate which they are now developing on the most advanced modern lines at Dagenham, 4½ miles from Silvertown. The East Ham By-Pass when completed in a year's time, will afford rapid and direct communication between Silvertown and this new Estate.

Apart from tenements and dwellings which will be destroyed, certain great undertakings, such as railways, riverside interests, etc., will be affected by the scheme (I have mentioned, for instance, the alteration of Canning Town Station).

Taking a long view, however, I am confident that in the outcome, nothing but benefit can accrue to all concerned, seeing what a handicap is now imposed on every local enterprise by the congestion of road transport. Certainly nothing is to be gained by postponing the improvement. If we wait until impending dock developments are put in hand, it is difficult to see how road works on a large scale can be initiated without causing intolerable inconvenience. In the most favourable circumstances, a scheme of the magnitude I have sketched, costing two or three million pounds, would require four or five years for its execution, and prudence would suggest that the re-housing should be begun well in advance of the rest of the project.

Allow me to say that I claim no originality in the authorship of the proposals I have laid before you this evening. It has merely been my aim to focus attention on what I believe to be one of the most urgent improvements conceivable, and one that I am proud to have the privilege of advocating.

If anyone is inclined to think that the proposals err on the side of extravagance, I would ask him to glance at two slides which show the stately magnificence of the road communications at the foreign ports of Marseilles and Havre.

May I be allowed to close this paper with an earnest appeal to London as a whole, London in its widest sense, to combine its incalculable resources for the launching of the great improvement scheme which I have described to you? Such a scheme has been advocated and debated for twenty years or more.

It can neither be treated as a local scheme to be undertaken by West Ham, nor as a national scheme to be financed solely by the government. The local factor and the national factor are not to be overlooked, but, rightly considered, the project is first and foremost an All-London task, the cost of which should be distributed over a wider region than the Metropolitan Police Area. So great a campaign demands united forces led by a spirit of vision and venture. The Home Counties which derive so much of their wealth and rateable value from their vicinity to London, should not stand aloof.

Again, what body could be more closely concerned in the improvement of traffic facilities to the Docks than the Port of London Authority? My experience of the willing collaboration of the London County Council and other metropolitan authorities in the construction of new arterial roads gives me confidence that they will not be found wanting on this occasion.

A host of other possible contributors come to my mind, but I refrain from mentioning them by name, as I should be loth to rob them of the credit of making the first advance, in the course of the discussion to which I am now eagerly looking forward.

DISCUSSION.

Sir Joseph Broodbank, in opening the discussion, said Sir Henry Maybury had treated the subject so exhaustively that there was little left for him to say, except to support most heartily the project which had been advocated that evening. Sir Henry Maybury had achieved many mighty works, for which his contemporaries were grateful, and for which posterity would be thankful. Sir Henry was one of those men who, to quote George Eliot, had the practical sense which seized upon opportunity and the energy which arrived in time. He was also one of those men who, once having taken up a subject, persisted in it, and would not drop it until something had been achieved. The present matter had not been taken up by the Ministry of Transport any too soon. Personally he knew most of the ports of Europe and of this country, and he could not call to mind any which had such bad road approaches as the London docks. The same could not be said of the railway, or of the river access, but the roads were very bad. Until the Ministry of Transport had taken up the subject seriously there had not been a single road, except one which he would mention later on, which was equal to what the Port of London, being the chief port of the world, was entitled to have.

One of the approaches to the Port of London had not been touched upon, but to his

mind, it was as bad as any, namely, the Whitechapel High Street, with what was known as Gardeners Corner, which throttled the whole of the dock traffic going from east to west.

The Chairman had referred to the part which the State might take in the making of great routes through this country. It was interesting, with regard to the London dock roads, to note that when the West India Dock and the East India Dock had been made there had been no road access to Poplar except the very narrow road which ran along the riverside. The West India Dock Company and the East India Dock Company had constructed a road themselves. The present Commercial Road with its spurs, the East India Dock Road and the West India Dock Road, had been constructed by the West India Dock Company and East India Dock Company, and had been worked as toll roads for many years. He thought, for a private venture, the successors of the directors of that day could be proud of those works. If it had been worth the while of those Companies to construct roads to their docks, surely it was worth the while of those concerned in the lower docks also to assist in making their roads. It was quite true that in 1855, when the Victoria Dock had been opened, nothing had been done in that way, but there was a reason for that. The Victoria Dock Company had depended on railway access and on water access; they never contemplated the developments in cartage, and in its early days cartage had been so expensive to the Victoria Dock, before the days of motors, that most of the traffic went by rail and not by road. That accounted for the fact that the accesses were so inferior at the present time to the lower docks. He heartily supported the general lines of the author's proposal. He had seen half a dozen schemes to overcome the trouble, but Sir Henry Maybury's commended itself to him as the cheapest. The only doubt he had with regard to it was whether it was necessary at any rate for the branch road to be so wide as 80 feet. It had to be remembered that the land on the South of the Victoria Dock and the Albert Dock was practically fully occupied by factories; there was not really much room for development. It had also to be borne in mind that the immediate future developments of docks in London were just as likely to take the form of an enlargement or development of the West India Dock area, the Millwall Dock area (which was far from developed) and the Surrey Dock, which was also in an undeveloped state. He would also like the audience to remember that the chief channel of the traffic which went in and out of the docks was carried by lighter, and not by cart or rail. That fact could not be ignored. The difference between a 60 ft. road and the present wretched thoroughfare was immense, and the expense could not be ignored. He saw that a figure of between £2,000,000 and £3,000,000 had been quoted. If such a scheme as the author had foreshadowed was going to be carried out, he did not think it would be found that £2,000,000 or £3,000,000 would cover the total cost. Independently, however, of such details he backed the scheme for all he was worth.

Sir Lynden Macassey, K.B.E., desired to express what he believed was the predominant feeling of every person who had listened to Sir Henry Maybury, namely, their deepest appreciation for the exceedingly able and masterly way in which he had dealt with an extraordinarily difficult subject. He remembered very well that when he had been Secretary to the Royal Commission, a proposal, not on the same lines exactly, but fulfilling the same purposes, had been pressed very strongly upon that Commission's attention by the inhabitants of the Silvertown district. Those people had put forward the view, which he thought every reasonable person must accept as the fair view, that they could not as a local Authority be called upon to foot the bill for an improvement so essentially necessary for the Port of London, and so vital for the interests of those who lived in the Metropolis; but there had to be borne in mind the fact that when, in the early days of the last century, three or four Royal Commissions urged that improvements of such a sort in the London area ought to be made a national cost, that proposal, which he could not help thinking was the right proposal, had been defeated by the Local Authorities, who, short-sightedly, insisted that each parish, on the principles of Bumbledon, should have the sole right to construct and look after their own roads. Over a hundred years ago the principle which Sir Henry had urged had been laid down by four Royal Commissions, namely, that these great improvements, which affected so materially the life and the economic welfare of the Metropolis, ought to be dealt with not upon parochial grounds but on national grounds. The ports of Marseilles and Havre entirely owed their road access to the far-sightedness of Napoleon. Unfortunately, we in this country had not a Napoleon (we might have one at the moment) in charge of the transport of this country, but there was great scope for adopting the same drastic measures as Napoleon had adopted.

He had had some time ago to go carefully into the evolution of the roads in the neighbourhood of London. The reason why the particular district with which Sir Henry Maybury had dealt, at the beginning of the last century, had been devoid of roads, dated back to Roman times. At the time of Cæsar's invasion the trade route from London to the Kentish ports went up to Lambeth, crossed the river from Lambeth to Westminster, and then went on to St. Albans, which was then the capital. When the capital had been changed to Colchester, the trade route diverged up to Southwark, crossed the river from Southwark to London, then went along the main road to Ilford right out to Colchester. From that time until Tudor days, and from Tudor days, with little modifications, to certainly the late Stewart days, the old maps showed absolutely nothing in the way of road improvements in the particular district dealt with by the paper. The reason was, of course, that every parish was looking after its roads in a way in which every

parish might be expected to look after its roads, and he personally saw no hope whatever of overcoming the very great transit difficulties which existed in such a district as Sir Henry Maybury had dealt with unless the matter was taken up by the Government, and unless not merely peaceful persuasion, but something in the nature of more direct action was adopted for the purpose, not merely of commandeering the State funds, but of extracting specifically local contributions from all the Local Authorities who would profit, as so many of them would, in respect of a scheme of the sort which had been outlined that evening.

MR. JACK JONES, M.P. (Mayor of West Ham), said for a great number of years West Ham had been doing its best to meet the situation. West Ham was spending on the average £5,000 per mile to maintain the roads in the particular area which Sir Henry Maybury had mentioned. Was not that a big contribution for a poor district, mainly composed of working men and women ? He had pointed out in the House of Commons that it was useless to spend millions of pounds in improving the docks if the roads leading to the docks were neglected. They in West Ham were quite willing to face their share of the responsibility, but they thought it was absolutely unfair that, simply because they happened to be right in the highway of the world's traffic, they should be asked to bear any more than their fair share. He had been told that the Victoria Dock Road was not a main road, but everybody in the East End of London knew that the East India Dock Road and the Victoria Dock Road led to India, China and Japan. They were the world's highways; they were not merely national, but inter-national, roads, and yet, when West Ham asked for help to enable them to carry out local improvements, they were refused it. West Ham was prepared to contribute their fair share to the cost, but because they happened to be a dockside district, because they happened to be not sufficiently influential to be able to impress their feelings upon those in authority, they could not be expected to foot the full bill, and an enormous bill it was.

He was sorry that Sir Joseph Broodbank had referred to the question of money. He himself would like to draw attention to the fact that millions of money were being lost to commerce and industry by the non-development of the dock roads. Another important fact was that thousands of working hours were lost in the course of a month by the labourers being held up by the swing bridges and level crossings. He asked Sir Joseph to reckon how much that cost, not to the people who could afford to lose it, but to the people who could not. The roads leading to the docks were practically bottle-necks all the way. Quite a different state of affairs existed in Liverpool, and why could not London have something of the same sort ? West Ham had been talking of Sir Henry Maybury's scheme on their Council for the past twenty years, but they had never been able to carry it out because their poverty had been their principal virtue. It was not a local question. There was an Imperial Exhibition now being held in London, and all parts of the Empire were being asked to come to it. He wanted them to come and see the Gateway of the Empire—not West Ham or Poplar, but the entrance to all the great possessions of the Empire, about which the Empire boasts so much. As he had said, it was not a local question; it was a national question, if not an Imperial question. West Ham would do its bit, and he hoped the rest of the Empire would do their bit.

CHIEF CONSTABLE A. BASSOM (Traffic Dept. New Scotland Yard) said the present congestion was due entirely to the inadequate roads and bottle-necks. That congestion would be all the more severe when the area became more developed. He would be the first to welcome any improvement to the roads in the dock area. The broader the roads the better would be the facilities for traffic, and the less number of police would be necessary in order to regulate the traffic, which would mean a great saving of expense.

SIR CYRIL KIRKPATRICK (Chief Engineer, Port of London Authority) said it had been a pleasure to him to hear Sir Henry Maybury give particulars of a really big scheme which would solve for all time, in his view, the difficulties at the western end of the Victoria Docks. He knew the scheme very well. It was one in which there were no physical difficulties, except the usual one of money, but as the Chairman was taking such an active interest in the matter, he felt sure the money would be found without any difficulty. There was just one point to which he desired to refer. Sir Henry Maybury had dealt only with one end of the Docks. There was another end which was in a still worse condition, which represented a bigger job, and which would take quite as many millions in order to improve it.

MR. G. W. HUMPHREYS, C.B.E. (Engineer to the London County Council), remarked that for the last twenty years he had heard the scheme put forward that night discussed, and he had heard it advocated in no mean eloquence by West Ham and the neighbouring authorities before the London County Council. The answer of the London County Council had been that their interests in the matter were really bounded by the River Lea. The sympathies of the London County Council, however, had extended far outside their boundaries, and the line of communication which existed at present, bad as it was, was a line of communication which had been furnished by the London County Council, and was the only existing road to the Dominions beyond the Seas. Something had been said that night about "direct action." That was the line he would like to take—to take the scheme in hand and get it done as fast as possible if only the funds were forthcoming.

SIR JOHN ONTARIO MILLER, K.C.S.I., (Member of the Port of London Authority), said he was

bound to say that the condition of things in the dock area was almost a scandal to the greatest city in the world. No slides or pictures could give one an idea of the amount of delay which was prevalent, and of the irritation which that daily caused. Mr. Jack Jones had referred to the way in which work-people were delayed in getting to their work by being held up at level crossings and swing bridges. Such conditions made for slovenliness and inefficiency in work. The removal of such a spirit by doing away with the obstructions which caused it would, he thought, be just as important as any of the other improvements which would be brought about by the scheme.

MR. E. B. TREDWEN (Hon. Treasurer, London Chamber of Commerce) remarked that everyone appeared to be agreed as to the absolute necessity for the improvements which had been suggested, and that it was only a question of money which stood in the way. It had been suggested that the Port of London should be asked to contribute substantially towards the expense of the scheme. He objected very strongly to that, for the reason that one of the things which at the present time was driving traffic away from the Port of London to other ports was that the charges in London were too high. The Port of London Authority was established by Act of Parliament to levy only such dues as would pay the interest upon its outlay. It was not, he took it, authorised to spend money outside its own territories and to charge the interest upon that expenditure against the goods that passed over its territories, or the ships that came into its docks. Therefore, the P.L.A. should not be asked in any way to contribute. The P.L.A. had already made a most magnificent contribution. It had built docks up to all the requirements of the Port to-day. He did not think it should have to increase its charges by making a contribution to the proposed roads, much as they were wanted.

MR. W. R. DAVIDGE, F.R.I.B.A., M. INST. C.E., said he was sorry to hear the remarks of the last speaker. It did seem to him essential that in all such matters a broad point of view should be taken. Sir Henry Maybury's scheme would be the first step to make the London Docks equal to the Liverpool Docks as far as road approaches were concerned. Although Sir Henry had referred in generous terms to the Marseilles and Havre dock roads, the roads which Sir Henry himself made were far better than the roads of the Marseilles and Havre docks. If Sir Henry brought into the present scheme the same perfection as he did with regard to his road surfaces elsewhere, it would be a very fine thing indeed.

MR. H. MARKS (Limehouse), briefly described how repairs to the roads retarded traffic and caused congestion.

THE CHAIRMAN, in moving a vote of thanks to the author for his paper, said he had the honour to be associated with Sir Henry Maybury in his work. It had not been decided how long he personally should stay in his present office, but while he was there he would certainly give Sir Henry all the help he could, in what he considered was very good work indeed. One could not be associated with transport in the sense in which he at present was without realising what a tremendous problem it was, and how remunerative it was to spend money in the way Sir Henry suggested. If one was looking for a real remunerative return for the State's money, he believed a better way could not be found than by building up the great main roads of the country and making transport easier. If that were done, so much the better it would be for industry. He did not agree with those people who were afraid to launch out in the matter. The country was suffering very badly from want of transport facilities, and the one way to encourage those who wanted to get on to the roads was to make the roads fit to get on to. It was well to get rid of the old idea that nothing should be done because a mistake might be made. It was far better to make mistakes than to do nothing at all.

The vote of thanks was then put and carried unanimously.

SIR HENRY MAYBURY, in reply, said he had taken a considerable amount of interest in the project. He had been associated with a scheme of sorts for improving the area since 1912. The audience had heard from Mr. Tredwen that, in his view, the Port of London Authority should not contribute towards the cost of the work. He was sorry that such a suggestion had been thrown out at the present stage, because to some extent it was discouraging, particularly when he remembered, as he did very well, that the first suggestion for such an improvement had come from the Port of London Authority when they approached the Road Board in 1912 and asked that Board to contribute to their scheme for improving the Victoria Dock Road. He was not, however, going to assume for a moment that he would not secure substantial financial, moral and actual support in getting the scheme through when they came to close quarters. The scheme would cost a lot of money, but, as Mr. Jack Jones had said, we could not afford not to spend the money in works of this kind. The country could not afford to have millions of money invested in those great Docks, and have the whole traffic from those docks throttled by the present wretched communications.

He was hopeful that the Chairman would not only see the scheme successfully carried through Parliament, but would have the glorious opportunity of opening the new road.

THE NATURAL RESOURCES OF HAYTI.

Although there are said to be considerable mineral deposits, it is generally agreed that the economic future of Hayti depends upon agriculture. Since the French colonial period there was, until

quite recently, no organised agriculture of any kind. Coffee, the staple product of the country, grows semi-wild, and similarly cotton, the second product of importance.

In 1918 an American corporation put 2,700 acres in the St. Michel Valley into cultivation and planted a long staple cotton from seed imported from the United States of America. The first crop was attacked by boll-rot. Subsequent experiments have shown that the native cotton is not susceptible to the disease. It seems therefore, writes H. M. Consul and Chargé d'Affaires at Port-au-Prince, that the future of cotton production in Hayti will depend upon improving the native cotton.

There are plantations of sugar cane in the plains of Leogane and the Cul-de-sac. The Haytian American Sugar Company is understood to be replanting its plantations with a type of cane imported from Porto Rico which resists disease and gives a greater production to the acre. This company during the past year produced some 9,500 tons of sugar.

In June, 1923, the California Packing Corporation obtained a concession for a term of fifty years for the cultivation and packing of pineapples. Planting has already commenced in the northern plain around Cape Haitien, and it is understood that results have been encouraging.

There is no doubt that agriculture in Hayti can be greatly developed. There is scope for the employment of capital in organised agricultural enterprise, but capital is discouraged by the lack of irrigation and transport. The proposed linking up of the present isolated branches of the "Compagnie Nationale des Chemins de Fer d'Haiti" and its extension into the central plain would go a long way to remove the latter disability. Irrigation, on account of the large capital investment involved, is a far more difficult problem. At the present time only a very small part of the central plain, a plateau 1,200 feet above sea level, and the rich alluvial valley of the river Artibonite, both regions being eminently suitable for organised enterprise, are capable of cultivation.

Until some means can be found to carry out adequate irrigation projects, attention must be confined to the conservation and economical distribution of the present available water and to the improvements of the staple products. It is thought that by improvements in handling and methods of marketing the production of coffee, which already amounts to 68 per cent. of all exports, could be increased.

The production of cotton, which now amounts to 15 per cent. of all products, can be increased by educating the peasant producers into taking more intelligent care of their plants.

Logwood, the third product in order of importance, has been taken from the areas around the open ports. Until more areas are opened up and facilities for transport made available, no appreciable increase in production can take place.

The Government, realising the importance of agriculture in the economic development of the country, has appointed an agricultural adviser, nominated by the President of the United States, in accordance with the expressed objects of the Haytian American Convention, and it is proposed to establish a system of agricultural education.

MEANS OF COMMUNICATION IN KASHGAR (Chinese Turkestan).

Roads. Reporting on the trade of Chinese Turkestan in 1922-23, H. M. Consul-General at Kashgar remarks that passable roads connect all the chief towns and larger villages of the Province, and it is possible to drive in a carriage almost anywhere within the great oases of Southern Hsinkiang without much difficulty. There is of course no metalling of any kind, but as the clay soil is firm and only about one per cent. of the traffic is wheel-borne, there are no ruts: indeed many of the roads would compare not unfavourably with the average rural unmetalled road in Europe. Bridges, albeit often rickety ones, over the numerous canals and streams are kept in some sort of repair on the "begar," forced labour system; over the big rivers ferries, with barges large enough to take 100 men or 20 horses at a time, are kept up. The only drawback from the point of view of the more rapid forms of wheeled transport is the frequency of shallow irrigation channels which cross the public highway and have to be negotiated slowly. Government rest-houses (often small and jerry-built affairs, it is true) are to be found at every stage along the main routes, in addition to the local *serais*. An interesting instance of enterprise in the opening up of new routes on the part of officials is afforded by the work of Ch'en Chi-shan of Khotan, who built rest-houses along the Khotan river route from Khotan right across the Takla Makan desert to the Tarim River south of Aksu, a matter of 300 miles, without a habitation except the huts of a few wandering shepherds.

Motoring is not to be recommended in Southern Hsinkiang; even if it were possible to transport a car across the high passes and sandy deserts which defend the country on every side, the irrigation channels mentioned above as crossing the roads every few yards would be a source of irritation even in the cultivated areas, while between the oases the exceedingly fine sand of the loess desert would make progress impossible without a caterpillar wheel attachment or similar contrivance.

Postal Service. The Post Office is a well-run department and the service is regular and efficient, though rates are necessarily high. Letters take two months to reach Kashgar from Inner China, parcels four to five months. From Kashgar to Keriya, 413 miles, including 150 miles of sandy desert, the postal couriers take ten days. The service between Keriya and railhead at Pingtang, nearly three thousand miles, is by far the longest courier-borne postal service in the world. The efficiency of the postal service is the more creditable in view of the enormous difficulties the Department has to contend with. These, to quote a

recent "Report on the Chinese Post Office," include "the vastness of this province of desert and mountains, the lack of reliable information, the scanty and nomadic population, the diversity of races and languages, the small proportion of the population able to read and write, the ignorance on the part of the public of postal regulations or even of the benefit to be derived from a postal service, the poor elements from which to recruit postal employees, the constant difficulty encountered not only in procuring but training couriers to to run along difficult lines through arid country where subsistence for neither man nor beast can be found, where there are dangerous rivers to negotiate, and where attacks on couriers by wandering tribes are frequent."

MEETINGS OF THE SOCIETY.

INDIAN SECTION.

MONDAY JUNE 30, at 4.30 o'clock.—J. C. FRENCH, I.C.S. "The Art of the Pāl Empire in Bengal." THE RIGHT HON. THE EARL OF RONALDSHAY, G.C.S.I., G.C.I.E., will preside.

DOMINIONS AND COLONIES SECTION.

MONDAY, JUNE 2, at 5 o'clock.—THE RT. HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member, Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates." THE RT. HON. VISCOUNT MILNER, K.G., G.C.B., G.C.M.G., will preside.

MONDAY, JUNE 16, at 4.30 o'clock.—C. V. CORLESS, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada."

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JUNE 2 .. Geographical Society, 135, New Bond Street, W., 8.30 p.m. Messrs. R. A. Frazer and E. F. Relf, "Central Spitzbergen and North East Land."

Farmers' Club, at the Surveyors' Institution, 12, Great George Street, S.W., 4 p.m. Mr. E. H. Godfrey, "Canadian Farming, with special reference to costs of production and conveyance of produce to English Ports."

Royal Institution, Albemarle Street, W., 5 p.m. General Meeting.

Ingénieurs Civils de France, Societé des, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., 5.30 p.m.

University Extension Lectures, at Gresham College, Basinghall Street, E.C., 6.15 p.m. Mr. A. Compton-Rickett, "Personal Forces in Modern Literature." (Lecture V., O. Henry.)

TUESDAY, JUNE 3 .. African Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Captain R. S. Rattray, "Arts and Crafts of Ashanti."

Colonial Institute, Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m.

Empire Mining and Metallurgical Congress, at the British Empire Exhibition, Wembley, 11 a.m (1), Viscount Long of Wraxall, Presidential Address, "Mineral Resources and their relation to the Prosperity and Development of the Empire." (2) Reading and Discussion of Papers.

Photographic Society, 35, Russell Square, W.C., 7 p.m. Paper on "An Analysis of Motion by Kinematography."

Royal Institution, Albemarle Street, W., 5.15 p.m. Major M. S. Tucker, "Acoustical Problems." (Lecture II.)

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m. Miss M. E. Durham, "West Balkans: Old Customs connected with Deaths, Blood Vengeance, Etc."

WEDNESDAY, JUNE 4 .. Empire Mining and Metallurgical Congress, at the British Empire Exhibition, Wembley, 10.30 p.m., Reading and Discussion of papers continued.

Archæological Institute, at the Society of Antiquaries, Burlington House, Piccadilly, W., 5 p.m. Dr. P. Norman, "Additional Examples of English Medieval Alabaster Carvings."

Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W., 8 p.m. "May Lecture." Dr. F. W. Aston, "Atoms and Isotopes."

University of London, University College, Gower Street, W.C., 5.30 p.m. Prof. H. Pirenne, "Les périodes de liberté et de réglementation dans l'histoire l'économique." (Lecture II.)

3 p.m. Prof. E. G. Gardner, "Problems of the Inferno of Dante." (Lecture III.)

At the London School of Economics, Houghton Street, W.C., 5.30 p.m. The Right Hon. L. C. Amery, "The Defences of the Empire."

THURSDAY, JUNE 5 .. Empire Mining and Metallurgical Congress, at the British Empire Exhibition, Wembley, 10.30 a.m. Reading and discussion of Papers, continued and concluded.

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Linnean Society, Burlington House, Piccadilly, W., 5 p.m.

Chemical Society, Burlington House, Piccadilly, W., 8 p.m. (1) Messrs. T. M. Lowry and H. S. French, "The Absorption Spectra of Camphor and of Camphorquinone." (2) Messrs. H. Burgess and T. M. Lowry, Studies of dynamic isomerism. Part XVI. Mutarotation of beryllium benzoylcamphor. Formation of an addition-compound with chloroform. The optical activity of beryllium.

Royal Institution, Albemarle Street, W., 5.15 p.m. Professor C. G. Seligman, "The Veddas of Ceylon."

University of London, University College, Gower Street, W.C., 5.30 p.m. Professor H. Pirenne, "Les Périodes de liberté et de réglementation dans l'histoiré Economique." (Lecture III.)

At King's College, Strand, W.C., 5.30 p.m. Professor A. J. Toynbee, "Outlines of Byzantine, Near Eastern and Modern Greek History. (378-1841 A.D.)"

FRIDAY, JUNE 6 .. Royal Institution, Albemarle Street, W., 9 p.m. Lord Rayleigh, "The Glow of Phosphorus."

Philological Society, University College, Gower Street, W.C., 5.30 p.m. "Dictionary Evening."

SATURDAY, JUNE 7 .. Royal Institution, Albemarle Street, W., 3 p.m. Mr. C. Nabokoff, "The Historical Trilogy of Count Alexis Tolstoi."

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FRIDAY, JUNE 6, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

DOMINIONS AND COLONIES SECTION.

TUESDAY, MAY, 27th, 1924; DR. J. W. EVANS, C.B.E., F.R.S., President of the Geological Society, in the Chair.

A paper entitled "A Sketch of the Geology and Mineral Resources of Cyprus" was read by Mr. C. Gilbert Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology.

The paper and discussion will be published in a subsequent number of the *Journal.*

TWENTY-THIRD ORDINARY MEETING.

WEDNESDAY, MAY 28th, 1924; LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Coriell, Louis Duncan, Baltimore, U.S.A.
Durran, William, London.
Oxley, Oswald John Philip, Durban, South Africa.
Raju, M. G., A.M.I.E.(Ind.)., Madras, India.

The following candidates were duly elected Fellows of the Society:—

Angle, Edward John, M.D., B.Sc., A.M., Nebraska, U.S.A.
Birch, Prof. T. Bruce, A.M., Ph.D., Springfield, Ohio, U.S.A.
Else, J., R.B.S., Nottingham.
Hansard, Colonel Arthur Clifton, C.M.G., London.
Henderson, Francis, J.P., Tunbridge Wells, Kent.
Hertz, Jacob, London.
Holdengarde, Theodore Albert Edward, Bulawayo, Rhodesia, S. Africa.
MacGallavry, Robert, Java, Netherlands East Indies.
Shehata, Nasif Girgio, Birmingham.

A paper on "The Position of the Arabs in Art and Literature" was read by MRS. ARTHUR MCGRATH (Rosita Forbes).

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, MAY 2ND, 1924.

SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Rector, Imperial College of Science and Technology, in the Chair.

THE CHAIRMAN, in introducing Professor Thorpe, explained that in 1918 the Indian Industrial Commission had arrived at the conclusion that no policy intended to foster industrial development in the country would have anything like an appreciable result unless it were preceded, and for that matter accompanied, by the active organisation of public services designed for conducting research work, especially on the raw materials of the country, as well as for the investigation of processes suitable for commercial development under Indian conditions. The Geological Survey of India was founded in 1850, and had demonstrated quite clearly that its cost was a profitable investment to the Indian taxpayer. There were also smaller services for botany and zoology, and their institution had proved equally wise. Nothing, however, had been done on systematic lines for chemistry, and on chemistry many of their industrial enterprises were based. They of the Commission had not felt justified themselves, for want of technical qualification, in going further than to sketch out the broad lines of advance, proposing that their suggestions should be criticised, and, if found to be generally suitable, should be elaborated by specialised committees. Those proposals had been accepted by the Government of India, and the Secretary of State had been asked in 1919 to select some suitable authority in this country to act as president of a committee of enquiry with regard to the development of chemistry. The chemists who were present that afternoon would agree that the Secretary of State had made a very wise selection in asking Prof. Thorpe to undertake that work, and personally he would like to say that the Imperial College had shown their regard for imperial interests in sparing Prof. Thorpe's valuable services. Prof. Thorpe's position as a distinguished research worker and teacher, and his familiarity with problems of a similar nature as a member of the Advisory Council for Scientific and Industrial Research, gave him very special qualifications for a task of that sort, and as the member of the Government

responsible for the Department with which Prof. Thorpe worked, he could testify to the thorough and conscientious way in which Prof. Thorpe had tackled the question when he arrived in India.

The paper read was :—

CHEMICAL RESEARCH IN INDIA.

By JOCELYN F. THORPE, C.B.E., D.Sc., Ph.D., F.I.C., F.R.S.,

Professor of Organic Chemistry, Imperial College of Science and Technology.

The Indian Industrial Commission, presided over by Sir Thomas Holland, issued its report in 1918. It had been formed in 1916, and was "instructed to examine and report upon the possibilities of further industrial development in India, and to submit its recommendations" with special reference to a number of specific questions, of which two only concern the subject of this paper. These were "(b) to ascertain whether and if so in what manner, Government can usefully give direct encouragement to industrial development—

(i) By rendering technical advice more freely available:

(ii) By the demonstration of the practical possibility on the commercial scale of particular industries.

The Report, which is an admirable summary of the present day conditions in industrial India, concludes with the following paragraph, which I cannot do better than quote, and adopt as the text of my paper this afternoon—"We have briefly sketched the lines of economic development along which India has moved since she first came into contact with western traders; and have described in more detail the commercial and industrial position to which these lines of development have led her. We have shown that this position has become in many ways disadvantageous to the interests of the country; and that India's industrial equipment is impaired by deficiencies which affect the interests of national safety. The industrial system is unevenly, and in most cases inadequately, developed; and the capitalists of the country, with a few notable exceptions, have, till now, left to other nations the work and the profit of manufacturing her valuable raw materials, or have allowed them to remain unutilised. A powerful and well-directed stimulus is needed to start the economic development of India along the path of progress. Such a stimulus can only be supplied by an organised system of technical, financial, and administrative assistance."

The commission made a number of recommendations dealing with the various items of its remit. It recommended, for example, the formation of several scientific services built up on lines which, it was hoped, would give an impetus to the development of industries based on the great natural resources of the country, for it was evident, as the passage quoted above shows, that the absence of any organised system of scientific research was the reason why many of these resources remained unexploited, and that, even where an industry had been established, had caused the principles on which it was based to be of the "rule of thumb" order without adequate regard to the scientific factors involved.

Among the services the formation of which was recommended was one dealing with chemistry, and, as this subject was rightly regarded as one of the foundations of all industrial development, the first effect given to the report of the Commission was to appoint a committee with instructions to "formulate proposals for the organisation of a Chemical Service for India and for the location and equipment of research laboratories." I was asked to act as Chairman of this committee, and with the object of obtaining an insight into the actual conditions, I toured through India during November and December of 1919 and January and February of 1920. In the course of the tour I visited all the important centres and was able to discuss the problems involved with many prominent officials and business men. I saw all the leading educational institutions and noted the facilities for research present in the chemical departments attached to them. It is evident that if an attempt is to be made to outline a scheme by which the industrial chemical needs of a country such as India are to be met, and an organisation for the purpose developed and maintained, it is necessary in the first instance to ascertain the condition of the scientific personnel from which recruits could be drawn to act initially as research workers in the service, and ultimately rise to the positions of directors. For one of the chief objects in view, besides ascertaining the best conditions for the establishment of the chemical service, was to find whether such a service could be expected to become self-contained,

from the Indian point of view, in the near future. For, although it was evident that a start would have to be made with an admixture of chemists possessing a European training, it was hoped that in the course of a few years the methods of scientific training carried out in the Indian Universities would have so far improved as to render it possible for them to supply an adequate number of fully qualified Indians for recruitment into the service. There is, in my opinion, no reason why the recruitment to the suggested service should not be wholly Indian in the near future, although I fear that for many years it will be necessary for the recruits to have at least one year's training in Europe prior to enlistment. Until education in India has improved it will, therefore, be necessary for the State to provide scholarships for carefully selected graduates to enable them to obtain this training. It seemed to me that many of the Indian Universities provided an adequate course of training in general chemistry, their M.Sc. degree being comparable with our B.Sc. Honours degree, but they are too busy preparing for the inevitable examinations to take much trouble about the need for a research training. No doubt facilities exist, but the teachers who should act as trainers in research are apparently overburdened with administrative and teaching duties, and cannot afford the time to carry out research even of the simplest kind. If India is to supply its own research chemists, the Universities must not only adequately train their chemistry students in the principles of chemistry, but must also, after graduation, provide a training in research methods of at least one or two years duration. The so-called technological institutes cannot help, because they are mainly trade schools in which certain branches of trade technique are taught. The subjects in which the students are instructed are usually connected with the industries of the district, and although there can be no question that these institutes are doing valuable and useful work, it is not likely that they will foster fundamental research, indeed it is not desirable that they should do so, for it is important that the student should receive his research training in some subject of general interest without direct commercial bearing. I know that many chemists do not agree with me on this point, but, the longer experience I gain as the head of a large research school, the more I realise that I am right, and that the introduction of research, likely to have a monetary value, into a research school develops and fosters cupidity, secretiveness, and every other anti-scientific vice. "Avant tout, développons l'âme scientifique avant de plonger le corps dans l'océan du commercialisme" is an extract from the preface to a recent French book, which is perhaps appropriate.

It will be seen, therefore, that India is at present poorly equipped to meet any demand for properly trained chemists, and cannot be expected to supply recruits for a chemical service unless, as mentioned later, the service itself can act as the research trainer. Nevertheless, the picture is not entirely dark, as it is possible that the Indian Institute of Science at Bangalore may, under the new régime, revert to its original purpose, and become the centre of research training in India. The Institute was originally projected by the late Mr. J. N. Tata with the object of encouraging post-graduate research in pure physical science, and, with this object in view, it was designed and equipped under the auspices of the late Sir William Ramsay. When I visited the Institute at Christmas, 1919, it was evident that the research work being carried on was mainly of a commercial character, and it was apparent that the original intention of the founder was not being carried out. Recently, a committee under the chairmanship of Sir William Pope has framed a scheme for the re-organisation of the Institute, and there is every reason to believe that, if the new organisation is found to be successful in practice, the Institute will become of real use to the Indian Empire, and will be of the greatest value in the development of several of the scientific services proposed by the Industrial Commission.

The conditions in the Universities are, I fear, not likely to improve if the evidence given before my Committees, by the Educational Commissioner with the Government of India, represents the settled and considered opinion of the educational authorities. This gentleman in his written evidence stated that —

> "The College Professor has little or no time for research, and the chief Professors, who may be styled University Professors, will be largely in the same position."

"In India a member of a College staff is generally burdened with the multifarious duties of College organisation."

These statements provide a full and sufficient reason for the fact that, hitherto, real university scientific work in India has been almost non-existent, and it is regrettable that such a state of affairs should be acquiesced in by those responsible for the educational policy of the country. It is significant that no chemist in India holds the Fellowship of the Royal Society. As a matter of fact the amount of new chemical knowledge emanating from India is exceedingly small, and out of all proportion to the number of University teachers and students, and the size and equipment of the University chemical laboratories. Apart from the output from the Government Departmental Laboratories of Agriculture and Forestry, to which reference will be made later, the only institutions carrying out publishable research are the College of Science, Calcutta, the University of Dacca and perhaps one or two others. The need for reorganisation is therefore urgent.

The general scheme outlined in the Report of the Industrial Commission for the establishment of a chemical service provided for the formation of a central research institute under the Government of India. The suggested organisation is given in the following paragraphs quoted from the report—"Taking Chemistry first, it would be possible, for administrative purposes, to divide the chemists into three fairly compact groups, which might be called, (*a*) agricultural, (*b*) organic and (*c*) mineral chemists. In many way the agricultural and the organic chemists would overlap, as many of the problems of agricultural chemistry are organic in character. It is desirable, however, in a country such as India, where agriculture is so extremely important, to give this branch of chemistry special consideration. The organic chemists would be occupied largely with problems connected with forest products, drugs, perfumes, essential oils and dyes, leather and sugar. Many of these officers would be eligible to officiate in the agricultural group. The mineral chemists would include metallurgists, the metallurgical inspectors and the chemists of the mints and Geological Survey. At some laboratory recognised as the headquarters of the service there should be at least one chemist who has specialised in physical chemistry, for a chemist of this type would deal with the physical problems connected with both the inorganic and organic substances. It seems to us that Dehra Dun possesses many advantages as a site for the headquarters of this as well as of other scientific services. The whole of the chemists would be under the control, for scientific purposes, of a senior officer, who might appropriately be called the Chief Chemist to the Government of India. Under him directly would be the staff of the headquarters laboratory, including the physical chemists and the specialists not assigned to provincial branches. The other three groups would be under the supervision of three Deputy Chief Chemists. Junior members of any of the three groups would be lent to Local Governments and the principal Government Departments for terms normally limited to five years. They would carry on the routine duties required, in some cases including teaching, and would undertake certain forms of research with the approval of the head of their service. All the results of scientific and practical value would be published in a serial recognised as the authoritative publication of the Indian Chemical Service. Such a serial would quickly establish its position in the scientific world, and would become a convenient medium for the publication also of papers by private chemists, resulting in the formation of an Indian School. At convenient intervals, most or all of the chemists might assemble for a week's conference, which should be open also to manufacturing and private chemists."

It will be seen, therefore, that the scheme as suggested by the Industrial Commission was a comprehensive one, and well fitted to meet the immediate industrial requirements of the country. It provided for the establishment of a central Government research institute at which both fundamental and practical research would be carried out, and which would serve as a nucleus from which chemists could be drawn to fill the various chemical posts throughout the Empire. There is little doubt that such a scheme would have been workable in practice for it was built on sound general lines and provided for practically indefinite expansion as occasion required.

Nevertheless, it was evident to me during the course of my tour that the Provinces would have nothing to do with such a scheme. Each and all of them were keenly alive to

the needs of the times. They recognised the necessity for scientific investigation into the conditions underlying their existing industries, and were fully aware that many of their natural resources remained undeveloped and could only be developed through the agency of scientific research, but they wished to do these things on their own behalf, unhampered by any restrictions which might be exercised by a central Government institution such as that suggested by the Industrial Commission. It was clear, owing to the strength with which this view was held, that any attempt to press the proposed organisation would have been attended with failure, and that the original scheme would not only have to be modified, but extended so as to provide for the establishment of a research institute in each Province.

Still, an extended scheme by which each Province would have its own research institute seemed practicable and, indeed, even an improvement on the original idea, provided that each Provincial Institute undertook to confine its activities, both fundamental and practical, to its own local immediate industrial needs, leaving a central institute under the Government to carry out those fundamental researches which underlay the industries of the country as a whole. A modified and extended scheme of this kind was recommended in the report of my Committee. In practice the Provincial Institutes would carry out research work on questions submitted to them by manufacturers in the Province, and would also carry out research work on new industries, likely, owing to the presence of the raw material in the Province or for other reasons, to be effectively established there. In England, two very strong and reasonable objections would be at once raised to such a scheme. The first would be that the proposed organisation would take away the livelihood of a number of useful consulting chemists, the second that it would provide the manufacturer with an excuse for not doing what, in his own interests, he ought to do, namely to establish and maintain a research laboratory of his own. But England is not India, and conditions which are present in the one country are absent in the other. No one would for one moment imagine that an organisation such as that outlined above would have the remotest chance of being successfully worked in England, where the conditions of manufacture are highly organised, and where most firms maintain research laboratories for their own purposes. Moreover, when any problems arise on which firms in England require expert advice, not forthcoming from their own research laboratories, they have at their command the services of a host of consulting chemists dealing with almost every branch of the science, and they can, if need be, ask the advice of one or other of the many experts dealing with special subjects in the Universities and University Colleges. There are, however, very few consulting chemists in India, most of the consulting advisory work, where such exists, being carried out in the Universities.

The second objection, namely, that the manufacturers might be induced, were the scheme to come into operation, to abandon or refrain from establishing research laboratories in their own works, would also not apply to Indian conditions. Indeed, the successful working of the proposed organisation would, in all probablity lead to an effect precisely opposite in character. Very few manufacturers in India maintain a staff of research chemists, and those that do would naturally only apply to the Provincial Research Institute for the solution of such problems as their own staffs had not the skill or time to attack. Work of this kind would, of course, have to be paid for by the manufacturers on an agreed scale of charges, but the chief and most important outcome would be, that the chemist or chemists who had solved the problem in the research institute would be loaned to the manufacturer for a sufficient period of time to enable them to place the new process on a working basis in the factory. In the case of a new industry, which might have been either initiated in the Provincial Research Institute itself or have been sent down from the central Government Institute for development, the Provincial Institute, after working out the details on the laboratory scale, the semi-large scale and the "unit" factory scale, would ascertain whether any existing firm of manufacturers were prepared to take over the process. If this was not possible, steps would be taken to find if any capitalists would form a syndicate to finance a new company for the purpose of starting the industry. Here again the chemists engaged on the new process would be transferred to the firm or syndicate for an agreed period of time, but they would retain a *lien* on the service

for a certain number of years, unless in the meantime they desired to become actual employees of the manufacturers, in which case they would pass out of the service with such pension as their position in the service provided.

The general effect would thus be to establish a research laboratory in the factory or to augment it if one already existed. The scheme would not in any way prevent manufacturers from carrying out "secret" research on problems connected with their own products, because this would be done in their own laboratories by their own chemists. The question of cost would have to be determined by agreement, but it would be the aim of the institute not to charge more than the actual cost price of the investigation, the object being to create new industries and to improve old ones for the general good of the country, and not to enable the institute to make any financial profit. The salaries of the transferred chemists would be paid by the manufacturers so long as they remained in their works; and every facility should be afforded to the chemists to pass from the service into the industry, for it is only in this way that the industry can become ultimately self-supporting, an object it is one of the purposes of the proposed service to achieve.

It might be thought that many of the investigations into the establishment of new industries would be, so to speak, "in the air," that the institute might find itself saddled with a number of completed investigations for which no market could be found, and which would thus remain unexploited; for one of the essential features of the organisation would be the avoidance of any semblance of competition with private commercial enterprise, its primary duties being to establish and assist, but, in no case, to compete with private effort. In practice, however, there is little doubt that no such difficulties would arise. The field to be investigated is an enormous one and there are numerous problems awaiting attack. There is no doubt that before any investigation was undertaken by the Institute, care would be taken to ascertain not only that the proposed new industry was based upon sound economic grounds, but also that, if successful, the necessary capital would be forthcoming to exploit it commercially. It might also be urged and was, indeed, so urged by Sir P. Rây in the note he appended to the report of my committee, that all the best men would pass out of the service into the industry, and that the Chemical Service would thus become a dumping ground for the incompetent, who would remain until they had completed their thirty or so years of service and then retire with a more or less adequate pension. This is, of course, a real objection, but it is one which has to be faced by every organisation which aims, as the Chemical Service would aim, at the improvement and development of the scientific status of a country. Those of us who spend our lives teaching research methods in our Universities and in our University Colleges have to reconcile ourselves to the inevitable fact that our best men leave us so soon as they have learnt our methods and have absorbed all that we can teach them. This does not mean that we are inefficient, on the contrary, it means that we are carrying out our work effectively. It is our business to instruct and lose, hoping that the source of supply will not fail to provide other good men equally competent to profit by our teaching. It is true that in our case the weaker men pass into minor posts and do not remain a burden on our hands, and to avoid this in the case of the proposed Chemical Service the Committee recommended the establishment of a stringent "efficiency bar" which would lead to the compulsory retirement of the hopelessly inefficient after a definite period of service. The success of the service would be determined by the rapidity with which men passed from the Universities into the service and thence into the industry.

In the Central Government Institute organised research of a fundamental character would be carried out. Much of this would arise during the operations conducted at the provincial institutes and would be referred by them to the central research institute; such reference would, however, only be made when the problem was either of general interest to the whole Empire, or, while fundamental in character, did not give promise of sufficiently quick practical results to warrant the provincial institute in attacking it. The decision on this point would rest with the provincial institute. It would be one of the chief duties of the Central Government Institute to survey the industrial possibilities of the Empire generally, and to initiate research having for its object the establishment of new industries in different parts of the country. In many cases,

investigations such as these would be handed over at an early stage to the particular provincial research institute in whose district the best facilities for the establishment of the industry existed, but in some instances, where the research was one of general interest to the whole Empire or of national importance as a key industry, the attack on it would be carried out by the central institute.

It will be seen, therefore, that the scheme suggested provided for the establishment of two very similar types of institution. One type, situated in each of the most suitable provincial centres, would be essentially practical in outlook. The other, situated at some convenient central place—the recommendation of Dehra Dun for this purpose by the Industrial Commission was endorsed by my Committee—would conduct research mainly fundamental in character, but would, nevertheless, deal in certain cases with investigations involving the practical establishment of a new industry. One of the main advantages of this arrangement would be that the personnel could, to a certain extent, be interchangeable, a most desirable feature when it is remembered that each institution must necessarily act as a training centre for the personnel it employs. No University or Technological system of training can be expected to discriminate between the men who are best fitted to act as leaders of research and those who are suited by natural characteristics and temperament to be leaders in the conduct of works practice. It is essential, where chemical manufactures are concerned, that each type of man should have received the same grounding, and this is adequately effected by a system involving a course of instruction up to the Honours graduation stage, followed by a training in research methods, the latter serving to impart the feeling of self-reliance and patience essential to success in a chemical worker, which cannot be obtained otherwise. It is the final problem, that is, how to supply the training in works practice, and, what is still more important, how to pick out the men most suited by temperament to profit by this training, which has to be solved not only in India but in this country also.

It is useless to expect any University or Technological Institution, however well equipped, to supply this training. Even if such an institution were provided with a complete equipment of the most up-to-date machinery of every conceivable kind, the mere working cost of instruction with such machinery would be prohibitive. Neither is it of advantage to label students chemical engineers or engineering chemists, because such terms not only help to accentuate the supposed difference between a "pure" and an "applied" chemist, but lends colour to the view that it is possible under our present system of education to produce such a hybrid. Chemical engineers are usually engineers masquerading as chemists, rarely chemists who are competent engineers.

In the proposed chemical service this very real problem of type would be met by a frequent interchange between the individuals comprising the junior personnel of the research staffs of the various institutes. Each man would, therefore, obtain his training in works practice, and if my experience as a teacher stands for anything, I am convinced that such training would serve as a method by which the men could be separated into two distinct classes, namely, those having a practical bias, and those whose instincts led them to take up work of a more fundamental character in the laboratory. The advantage gained by men working in the research laboratory by having received this practical training is obvious. Each man would be able to render himself intelligible to his fellows, and the "pure," that is, the research chemists, and the "applied," that is, the works chemists, would not be placed in their own water-tight compartments, as is, unfortunately, too often the case at the present time.

Each Provincial Institute, as well as the Central Government Institute, would, therefore, be provided with a main general research laboratory equipped in the usual manner, a semi-large scale laboratory provided with small scale plant suitable for making material on, say, the 10 lbs. scale, and another laboratory where the "unit" scale plant could be erected. It is probable that the two latter types could be combined into one laboratory. All that is required is an open floor space on which plant can be built up and pulled to pieces at will; it would have to be provided with the usual services of gas, water, etc. These proposals imply that, besides the main chemical staff, each institute would have to be provided with a suitable staff of engineers, whose main duty would be to act as instruc-

tors in general engineering practice. It is not considered necessary that the chemists forming the service should possess more than a working knowledge of engineering. A complete knowledge of both engineering and chemistry, desirable though it undoubtedly is, would be impossible of attainment in the time an ordinary individual can devote to his education. Moreover, it is unnecessary, because all that is required is for the chemist to possess a sufficient knowledge of engineering science, especially of machine drawing and workshop practice, to enable him to make himself intelligible to an engineer or draughtsman. In my opinion, it is essential that every chemist should possess such a working knowledge of engineering. It is, however, astonishingly difficult to get teachers of engineering to see this point of view. There is no difficulty in making them realise that no harm is done to an engineer by giving him a working knowledge of the principles of chemistry, but when it is suggested that a chemist would be benefited by a similar amount of engineering knowledge, it is usually stated that the training of an engineer takes at least three years, and cannot be effected in any shorter period.

Fortunately, during my Indian tour, I was able to find in the College of Engineering at Poona an institution which did not take this view, and which was prepared to give the chemists preparing for the chemical service an adequate instruction in engineering extending over a period of six months.

This matter is of such importance from the point of view of the general education of the chemist, not only in India but in this country as well, that I venture to quote from the letter written by Mr. C. Graham Smith, the Professor of Engineering at Poona, on the subject—"I was impressed with the arguments of the Committee that came to the College of Engineering the other day, in which they considered that the chemist could learn all that was necessary in a short course covering a period of, say, six months. I have discussed the question with a number of men, and none of them considered that a course of six months was sufficient, but on examination, they came round to the conclusion that what was required could be done in the period already stated. The time available might be divided more or less as follows—15 per cent. carpentry, 35 per cent. engineering shops, smithy, etc., 20 per cent., sketching, and 30 per cent. mechanical and elementary drawing, making in all 50 per cent. shops and 50 per cent. drawing.

The proposed scheme for the establishment of a chemical service would have to start in a small way, and, no doubt, in many of the Provinces use could be made of some existing institute to act as the provincial research institute, until funds were available for the erection and equipment of a building especially designed for the purpose. The executive committee controlling the service would have to be a representative body, because it would be on its recommendation that the chemists to the various Government Departments would be appointed. It should comprise the chief chemist of the various Provincial Institutes with the chief chemist of the Central Government Institute as Chairman. This body should be able to make all the recommendations necessary for the working of the service direct to the Government concerned. The chief initial cost would be incurred by the erection and equipment of the new Government Research institute at Dehra Dun, but it is understood that some of the money, at any rate, has been allotted for this purpose. Indeed, it is likely that a large capital expenditure and a considerable income would be necessary in order to start the scheme and to place it initially on a sure financial basis, because, as has already been mentioned, it is not proposed that any attempt should be made to make the Service self-supporting, and the equipment of the new laboratories would have to be completely up-to-date. No doubt a considerable annual income would be ultimately obtained by the sale of new processes and improved methods of manufacture to firms and syndicates, and this amount would be set against the annual cost of each institute, but it would not be large enough to do more than defray the partial cost of maintenance, and a considerable annual grant would be necessary in addition. Nevertheless, if the Service is to succeed, the Government must take the long view, and bear in mind, chiefly, the increase in wealth to be obtained by the development of the natural resources of the country. The opportunity is a splendid one, but to take advantage of it effectively requires courage and vision.

Sir Prafulla Rây, who framed a note to the Report of my Committee dealing with the objections from his point of view to the proposed service, commented on the undesirability of introducing yet another service

into the conduct of Indian affairs. This is a point on which I am not competent to express any opinion of value, but I have noticed among my Indian students an astonishing unanimity in their desire to enter a Government Service at the earliest possible moment. I have not hitherto ascribed this wish on their part to the desire to obtain, as Sir Prafulla suggests, a "soft job" in which they can be "easy going" and "secure of drawing their monthly cheque," because it has always seemed to me that the competition for advancement must always be just as keen within a service as outside it. Is it not true, rather, that this desire to enter Government employ is due to the lack of stable conditions in India, to the absence of security of tenure, and to the impossibility of obtaining a post outside the Government service likely to yield an assured income? It is conditions such as these which also prevent the best Indian brains from adopting a chemical career in the Universities, and lead them to take up one or other of the more lucrative professions. Surely an organised service, such as the proposed Chemical Service, would not only provide a means of secure employment for chemists, but would also, by absorbing a constant stream of recruits from the University laboratories, tend to raise the standard of teaching in these institutions. Sir P. Rây thinks that the only solution of the Indian industrial problem is to be found in the old method, by which new industries are started by the importation of some expert or experts from abroad, and this method is undoubtedly a good one when the proposed new industry is based upon known knowledge, and when firms can be found abroad who are willing to part with their experts for the purpose of instituting a rival industry in another country. It is a method the possibilities of which would have to be explored by the proposed Chemical Service. But it must be remembered that the chemical industry is not like, for example, the cotton industry, in which the large firms of manufacturing engineers find it to their advantage, in order to sell their machines, to see that their clients are fully instructed in their use. In the chemical industry the men who really know are either retained by the manufacturing firm abroad or are bound to them by agreements, which prevent them from transferring their knowledge elsewhere. I am at one with Sir P. Rây in thinking that the institution of a chemical service such as that proposed would be the worst possible solution of the problem in a country in which the conditions of manufacture were developed, but I am convinced that it is the only solution possible under Indian conditions. India requires team work, and organised team work is, in my opinion, the only method which will bring about the desired result. For the natural resources of India are such that there is no reason why she should not take her place among the chief commercial nations of the world.

One has only to realise the results which were obtained during the war by the Indian Munition Board to understand the effect which organised scientific team work is likely to have on the Chemical Industries of the country.

Another objection raised by Sir P. Rây was that the proposed organisation would be top heavy; but this is, of course, inevitable in the circumstances, at any rate, to commence with. If the general scheme were adopted the first action would be to appoint the Director of the Central Government Institute and a Director for each of the Provincial Institutes, who would be responsible for elaborating the details of the scheme; they would have to appoint their staffs and erect or adapt their laboratories.

It is inevitable that an organisation such as this should be built from the top downwards. His objection as to cost I have already dealt with; the scheme would undoubtedly be costly in the initial stages, but the return would, in my opinion, be a hundredfold.

The industrial resources of India, so far as her chemical industries are concerned, may be classified under two heads, namely, those derived from mineral sources, and those based on substances which are of vegetable origin. Excepting in so far as coal and its products are concerned, the former belong to the sphere of inorganic chemistry, the organic raw materials being those which are obtainable from coal and oil, and from the wide range of substances present in the forests, and also those obtainable from agricultural sources.

The nature and extent of the mineral deposits of India have been systematically examined by the Geological Survey, but except in very special cases, the survey has not been carried to a point which would warrant commercial exploitation. It would be one of the first duties of the proposed

chemical service to carry out, in conjunction with the geologists, a thorough survey of the possibilities underlying the commercial exploitation of several mineral deposits, a description of which will be found in the Report of the Industrial Commission. India is by no means deficient in the raw material necessary for the production of the essential heavy chemicals, sulphuric, nitric and hydrochloric acids and caustic alkali. It is true that sulphur does not occur native, but a wide source of this element exists in the zinc blende mines of Burma, which have not, however, yet been exploited for this purpose. Sodium chloride and nitrate are abundant, and no doubt the electric power schemes which are now being developed in southern India and elsewhere will lend themselves in due course for the preparation of nitrogenous products from atmospheric nitrogen. The salt deposits of the Kharagoda district, north of Bombay, which have recently been analysed, indicate a possible source of potassium and bromine which should clearly be explored.

The two chief Departments which have hitherto carried out chemical research in their respective spheres are the Department of Agriculture and the Forest Department, and great improvements have been effected under their auspices. The scientific officers attached to the Agricultural Research Institute at Pusa include mycologists, economic botanists, entomologists, bacteriologists and chemists. In addition there are one or two recognised agriculturists in each province. At the time of my visit I was greatly struck with the thorough manner in which the various problems being dealt with at the Pusa Institute were being attacked, and with the character of the work which had already been accomplished. The Industrial Commission in discussing its plans for the formation of scientific services, points out, however, certain disadvantages attaching to an organisation such as this, in which the subject and not the science is the bond, and the question is one of considerable interest in connexion with a subject such as Agriculture, which includes a number of sciences belonging both to the physical and biological sections.

The war brought to light the great value of team work both in India and at home. The wonderful developments accomplished then and the great results achieved by the chemists in both countries are now matters of common knowledge. In this country we have taken the lesson to heart, and already many of the fundamental problems underlying our industries are being attacked by Research organisations formed for the purpose by the manufacturers concerned. The national well-being of India demands that every effort should likewise be made on her behalf to promote research in science, in order that her existing industries may be stabilised and her great natural resources developed.

In these days of specialisation there is always a danger that the specialist may lose touch with the general advance of the parent science, and, while this is probably not a great disadvantage when the ordinary problems of, say, agriculture are being attacked, it becomes a grave handicap when research, based on the most recent knowledge, has to be carried out in order to settle or establish some fundamental question or principle. There can be no doubt, therefore, of the advantages attaching to a system by which chemists, skilled in some particular branch of chemistry, could be lent to the Agricultural Department for the purpose of investigating some particular problem in the solution of which their special knowledge was needed. In these circumstances, the Department would not merely have to rely on the services of a few men whose training and experience might or might not fit them for the purpose in view, but would have the whole strength of the Chemical service to draw on in order to obtain the right man. It seems, therefore, definitely desirable that the chemists of the agricultural service should belong to the Chemical Service.

The Forest Department is in much the same position. The Forest Research Institute is at Dehra Dun, and here, as at Pusa, a number of scientific officers carry out research work in their own subjects. The chemical products are of great variety and extent, and would well repay the cost of a staff of investigators many times the size of that at present at work. Already much has been done both as regards commercial exploitation and scientific research, the former being illustrated by the resin and turpentine factory at Jallo, and the latter by the recent discovery of carene, in the turpentine oil derived from the Pinus Longifolius, by Simonsen. But the possibilities of further development are enormous, and include the search for and extraction of plant alkaloids, the utilisation of the forest grasses for fermentation purposes, and the com-

mercial exploitation of the vast number of essential oils which everywhere abound. These problems require the services of a number of specialists for their solution, and it is only by means of a chemical service that such specialists could be supplied.

The chief source of coal occurs in Bengal and Bihar, but only about 5 per cent. of the yearly output is available for use as coke, and, therefore, for the preparation of by-products. When I visited the Tata Iron and Steel Company's works at Jamshedpur, the recovery plant was not yet built, and coke was being made in non-recovery Coppee ovens. Since then, I believe, a complete recovery plant has been installed, and many valuable by-products must now be available for use in the organic chemical industry.

DISCUSSION.

The Chairman (Sir Thomas H. Holland), said the paper, for the purposes of discussion, fell naturally into two main divisions. First of all there was the general relation of research and chemistry to the development of chemical industries, and, secondly, there was the application of Prof. Thorpe's principles to the special conditions of India.

Before inviting discussion he desired to refer to the special conditions which the Industrial Commission had in mind when they made their original suggestion in 1918. One part of the question had already been dealt with by Prof. Thorpe, who had explained that the existing special conditions of India necessitated direct Government activity in organising research rather than the indirect subsidy of University institutions, such as we were accustomed to in this country. Those who had criticised the original proposals of the Industrial Commission had had in mind their experience of institutions here, where private enterprise and local effort had always preceded Government activity and Government recognition. The chief fault in the criticisms that had been made here, as well as those which had been made in India, had been due to a failure to distinguish between the terms "Service" and "Department"—a distinction which had been very carefully preserved by the Industrial Commission in their Report, and especially by the Government in formulating the terms of reference for Prof. Thorpe's Committee. As a member of a service, an officer had certain covenanted privileges of pay and of pension, and, in the case of an All-India service, of prestige. That last feature had a market value even among devoted scientific workers. As a member of a department an officer was subject to discipline in his work. His body belonged to the Department and his soul to the service; but Local Governments, especially under reformed conditions, preferred scientific officers to be theirs, both body and soul. The Industrial Commission had proposed that a member of the All-India Chemical Service should be lent to Local Governments or to special departments for periods or for a special line of investigation, to be returned if found unsuitable, or to be transferred to other parts of India in order that the requirements of the chemical research work, for which they were specially fitted, might be carried on, and that they should not become limited by simply local conditions. In order to form some idea of the existing conditions of service for a chemist in India, he would like the audience to read paragraph 118 of the Industrial Commission's Report, where they would find a list of the chemists who were employed in India in Government service. They occurred in ones and twos, very rarely in threes, with a total of about 60 chemists altogether. They had to act as handmaidens to various departments, some under scientific officers (but very rarely), and others under officers who had no interest whatever in scientific research. Most of them were required to give authoritative advice on every branch of chemistry. They were in absolutely isolated posts, generally with no official prospects of promotion, and no possibility of obtaining a position which should suit and satisfy any man of energy, ability and reasonable ambition. It was at present in those circumstances utterly impossible in India to obtain a collective opinion on any chemical question. If one compared those conditions of what one might easily call a state of organised confusion with the conditions under which geologists were employed, one found that the geologists were organised in a service which was also at the same time a department. That department of officers was under the control of a director, who was one of their own caste. He occupied *ex officio* an honoured position as one of the four principal Geological Survey Directors of the world. As a result of the unity of his department and service, and as a result of the organisation of that department, the officers had the work they were fitted to do—a palaeontologist did palaeontology and a mineralogist did mineralogy. It was possible for any one, whether a Government department, or a private person, to obtain an authoritative opinion through the Director on any geological question in India. That was not possible at present with regard to chemistry. The Geological Survey of India had issued its serial publications of memoirs and records for the past 70 years, and, by the exchange of those publications with scientific institutions in other parts of the world, it had now established for its special use in Calcutta, and without any additional funds being spent in the purchase of books, one of the finest geological reference libraries outside Washington.

One of the members of Prof. Thorpe's Committee had criticised the proposal for an All-India Chemical Service by assuming that a Government institution necessarily led to stagnation, delay, procrastination, the destruction of freedom, hidebound conditions and the destruction of originality in scientific work. What was the result, as tested by the appreciation of the scientific world? There were more than three times as many chemists employed by the Government in India as there were geologists;

but outside the Agricultural Department, the published work of the chemists in India was practically negligible beside the 150 volumes of valuable papers which had been issued by the Geological Survey. The small body of Geological Survey officers in India were seldom without a sprinkling of Fellows of the Royal Society among them; but so far as he knew, in the whole history of India only one chemist had to that extent been recognised by his fellow workers. Sir Prafulla Ray was afraid that chemists would be attracted from the Government service by manufacturing firms, and that consequently the service would become an insoluble residue of the least efficient members. Prof. Thorpe had already referred to, and to some extent had removed the impression caused by, that argument. There was one other feature to which he might have called attention. If the men in the Chemical Service were attracted to firms, it would only be as the result of the success of the service itself in developing the conditions which facilitated commercial success. Nothing could possibly be better for India. He wished he were optimistic enough to predict in the future the appreciable degeneration and final destruction of the Chemical Service in a way so eminently satisfactory. The Chemical Service would have done its duty to the Indian taxpayer if it proved in that way that it was no longer wanted. It would not be easy, he was afraid, to demonstrate the truth of his conclusion, but it would be very easy indeed to demonstrate the soundness of Sir Prafulla Ray's views, by refusing to establish the service at all. There was no doubt, that without it there would be no temptation for any chemist to leave the Government service. There would be no employment for him outside the Government service. But it was better, again, to judge by experience than merely to predict from imagination. What had happened to the officers of the Geological Survey? Their work had been conducted in India during a time which had been attended by a very successful mining development. He could not recollect more than two officers in the whole history of the Geological Survey who had given up their position, their prestige and their prospects of promotion in the service in order to accept improved immediate emoluments from a mining company, and those two men, he thought, might fairly be described as not entirely the best two in the service, nor did he think it would be unfair either to them or to the Department to say that their departure had not lowered the average quality of the residue. The reason was perfectly simple. An officer who belonged to a service of that sort knew quite well that he was well off, and he was not going to give up a service of which he was proud unless he was paid at rates which commercial firms were not likely to offer except under conditions of success, which could be looked forward to without any fear.

There was one other feature to which Prof. Thorpe had referred but had not summarised in a way which he thought might help one to value such a service, and that was the value of a systematic survey of raw materials. It was not research work on purely chemical problems or chemical processes which would occupy the service in its early days so much as a mere survey of information regarding the raw materials which India possessed in abundance. That survey could not be done systematically by any individual or any firm. It was the duty of Government. It would not be done, either, by any Local Government. The strong desire which was now being shown in India for Provincial control was proceeding without discriminating between two totally different functions of Government officials. There was the executive function of an official, for which decentralisation to the very full should be encouraged and allowed; and there was the advisory function, which required the very highest form of specialisation, and, therefore, could only be accomplished by co-operation and a central organisation of a kind which would enable the country to employ the very best form of specialist. The scientific officer's work in research and in advice was almost entirely of the second class—the advisory class, where it was far more important to get the opinion of a specialist than it was to act quickly and promptly. For executive work it was necessary to act promptly on the spot with whatever officer one had—not necessarily the best. For advisory work, deliberation, in order to obtain advice from the specialist, was absolutely necessary. Provincialisation and de-centralisation were valuable so long as there was a definite discrimination between those two utterly distinct functions of Government officials.

Professor Henry E. Armstrong, F.R.S., said the Chairman had implied that little, if anything, had been done in India in chemistry, although much had been done in geology; perhaps that was scarcely a fair statement, as agriculture had been well cared for over a considerable period. He thought himself that the subject of a scientific service needed discussion mainly from the agricultural point of view. It was not a question, at present, of laying down the conditions of a Service, so much as of securing some understanding throughout India of the importance of the aid which could be rendered to the country through systematic scientific inquiry. As was known, he had blue'd if not burned his fingers over indigo, and the experience he had had in that connexion was not a heartening one. A few years ago they were on the way to securing the rehabilitation of the indigo industry in India and of meeting foreign, especially German competition; but the Government and the India Office had elected to "throw up the sponge" and in a brief period the Germans had regained the position they had before the war. If the Government could not understand a simple proposition such as indigo presented, he failed to see how the much more difficult problem of a complete chemical service was to be worked out. He had noticed that Sir Alfred Mond, on his return recently from India, had spoken in very clear terms of the great need of agricultural development in India, in order that there might be an increased

output of food crops for the people. The indigo work had been directly contributory to that end. He thought that, in the main, the scientific work should be done more particularly with the object of improving the agricultural conditions in India. He agreed, however, with the Chairman that there ought to be a complete scientific survey of Indian resources on the chemical side. The author had argued that "there is no reason why the recruitment of the suggested service should not be wholly Indian in the near future." That was a question which should be very fully discussed. So far as he personally could see, the mentality of the Eastern nations was not such as to make them equal to the Westerns as experimental workers. His feeling was, however, that a real beginning should be made somewhere and that some one person should be got to take charge who had enthusiasm and the necessary genius for the work—that was the difficulty, to get men of the necessary mental ability for work such as was required. We were suffering already from want of men of ability in this country. It had been hoped that, at the end of the War, instead of men of intelligence mostly going to the Bar and to the professions, more would devote themselves to science; unfortunately, the tendency had been the other way. Unless men could be attracted to science, progress would not be such as was hoped for. Everything depended on getting hold of leaders. There were Research Institutes, in a large number of places, in various countries; on the whole, however, the results were not satisfactory, except in the very few cases in which a genius controlled the work. What most concerned him, at the present time, was the fact that when he talked to young men about undertaking work in India, he found that they almost all showed none of the courage which the young men of the past had shown in going abroad, in putting their backs against the wall and succeeding by their determination; they all asked for an assured future. He was afraid that the non-existence of a spirit of enterprise in the young men of to-day stood very much in the way of the development of any such Service as Professor Thorpe contemplated.

Prof. W. A. Bone, D.Sc., Ph.D., F.R.S., said Prof. Thorpe had already disarmed a good deal of possible criticism by saying that the scheme set forth in the paper was one devised for Indian conditions at the present time, and not one which he would recommend for this country. Personally he had not been to India, and knew it only in a very general way. Prof. Thorpe had been there, and had seen the present state of chemical science in India in teaching and research, and he was quite willing to take Prof. Thorpe's recommendations as emanating from a very good judge of what ought to be done under the given conditions. He entirely agreed with Prof. Armstrong that the good which would be got out of any scheme of such a nature as that indicated would depend upon whether the right man could be got to start it. A man of the right type of genius was necessary, and he was not always to be found. It was much easier to draw up a scheme of the kind set out in the paper than to find the men who were capable of carrying it out. He thought the comparative failure of some of the research institutions which had been started in this country in recent years was due to the fact that that important consideration had not been sufficiently appreciated. By what means could men of the right qualifications be induced to go to India (that was, if they could be found), and start such a scheme? That, it seemed to him, was a point which Prof. Thorpe might usefully elaborate later in an addendum to the paper. Personally, he had difficulty in seeing where, at the present time, a sufficient number of the right type of men were to be found to carry out so comprehensive a scheme as that indicated by Prof. Thorpe. No doubt the scheme would be started on a smaller scale than that set out in the paper, and he agreed with the Chairman that initially one of the first things to do would be to survey the natural resources of India from the chemical standpoint.

Prof. J. W. Hinchley, A.R.S.M., F.I.C., said he was interested in the subject of a chemical service, not for India alone, but because he thought such a scheme was a step in the right direction. He only wished that some definitely correlated scheme of an adequate chemical service could be developed for this country, to do away with the present disjointed arrangement that existed. If such a thing could be brought about, the profession of chemist would be considerably improved. He would like to say something with reference to the paper, but it was quite possible that since his experience had not been gained in India, it might not be of special application to the problem set forth by Prof. Thorpe. He had been very interested in its solution, but there were some singular inconsistencies. He knew they were not real but only imaginary. For example, he would say: "Carry out this research, but for God's sake, do not let it be worth anything, because if you do you are going to demoralise the research worker." The filthy lucre point of view was one that had to be faced. Unless the research work increased material prosperity, no country would subsidise it. Prof. Thorpe had described the training of the chemists that he would propose for dealing with the problem of India, and had stated that chemical engineers were engineers masquerading as chemists or chemists pretending to be engineers, and then proceeded to describe his process of producing chemists pretending to be engineers. Personally, he would like to say that the reason why there were practically no satisfactory chemical engineers in existence was that in this country, at any rate, the educational institutions did not give them facilities. When he himself had been a student and had wished to become a chemical engineer, he had taken metallurgy in his third year for his Associateship, because it was a specialised branch of chemical engineering which had of necessity been developed first. A metallurgist might be an

applied chemist or he might be a chemical engineer. At any rate, metallurgy was one of the earliest examples of the development of chemical engineering, and he did not think any metallurgist would consent to be called an engineer masquerading as a chemist or a chemist masquerading an an engineer.

With regard to the training of men who wished to take their place in industry as organisers and managers of industry, he was certain that the right man to fill such positions was the man who had a chance to be trained, and who had the inclination that way, both as an engineer and as a chemist during his scholastic career, and in that respect he would like to say that one could not aim at producing a complete engineer, or a complete chemist. He would like to find the chemist who pretended to a complete knowledge of chemistry. He was certain there was no engineer who claimed a complete knowledge of engineering. With regard to chemical engineering, the heart-breaking experience of the War with regard to plants put up by the co-operation of chemists and engineers ought to be enough to convince any man who came in contact with them of the necessity of training men who went into industry after a training both in engineering and in chemistry.

The Institution of Chemical Engineers had been recently formed by a number of men who had seen the necessities of the situation. It had first been projected by Lord Moulton, who, if he had lived, would have been the first President of the Institution. It was now drafting a scheme to put before the educational authorities with regard to the training adequate for the practice of chemical engineering. He was inclined to think that such a scheme would be just as valuable in India as it would be at home. He was very glad that Prof. Thorpe's conversion to the chemical engineer was taking place on the usual lines. He had come across gentlemen of the same type who had been just as inclined towards chemical engineering, but who had gradually been converted in practically the same way. He congratulated Prof. Thorpe on his scheme, and he hoped that something would come of it.

Sir Alfred Chatterton, C.I.E., F.C.G.I., said, that during the last twenty years a considerable number of Indian trained chemists had been working under him at problems connected with the development of industries in the South of India, and he desired to pay a small tribute to the very useful work which some of these men had done. He gathered from the paper that Prof. Thorpe had not been favourably impressed with the work going on in the Indian Institute of Science, at the time of his visit, and that he regarded the obviously commercial aspect of some of the work as opposed to the aims and objects of the founder. On this point he (the speaker) would like to quote from a letter he had received from Sir William Ramsay, in 1901, just after his visit to India to advise Mr. Tata, in which it was definitely stated that the object of the proposed Institute was "to create and develop chemico-engineering industries all over India." No doubt in the lengthy discussions which preceded the actual foundation of the Institute, attempts had been made to modify this clearly defined idea, but it had persistently made its influence felt all through the deliberations of the Council which was responsible for the administration of the Institute. It must not be forgotten that the Institute of Science was the pioneer of industrial scientific research in India and that naturally, in the absence of experience, mistakes had been made and that the Institute as it was working to-day was the product of evolutionary processes of a very strenuous character. He desired to asociate himself with the anticipations of Prof. Thorpe in regard to the future, but he also thought that the very valuable work done by Dr. Travers, the first Director of the Institute, and some of his colleagues should not be lost sight of. In the course of twelve years' work at the Institute, it had furnished concrete illustrations of the various problems that would have to be tackled if chemical science was to make rapid progress in India, and in that respect at any rate the ground had been cleared for the Committee over which Prof. Thorpe had presided. Apart from the training of students, who came from all parts of India, the resources of the Institute had been mainly utilised by the Governments of Madras, Mysore and Hyderabad. Very valuable assistance had been rendered in the solution of industrial problems arising out of the war. As Director of Industries successively in Madras and Mysore, he had received much help from the Institute in respect to the work on which he was personally engaged, whilst as a Member of the Council he was in a position to testify that purely scientific research work had been by no means neglected.

Dr. J. A. Voelcker, in proposing a vote of thanks to Prof. Thorpe for his carefully prepared paper, said the problem dealt with was no easy one. Prof. Thorpe had weighed all the considerations in the case, not merely on abstract principles, but with special reference to the particular conditions of India itself—a point which many people were apt to forget. The Report of the Indian Industrial Commission practically summed itself up in the advocacy of the formation of a chemical service for India. He was sure that all who had to do with chemical matters, whether from an agricultural or other point of view, would agree that if a man was to reach the highest point in any branch of applied science, he must have had the ground-work at the outset, and he must also have had a training in research methods. Without some such Service as Prof. Thorpe had indicated, progress would be limited; but that it had been of quite such a limited nature as had been stated was, to his mind, somewhat doubtful. Certainly in the field of agriculture enormous advances had been made—although he did not say that the men engaged therein would not have been very much better if they had gone through some such training as had been indicated. His mind was taken back to 34 years ago, when he

was in India. At that time there was not an agricultural chemist in the country, and there were only one or two experimental stations, which did little more than grow seed and test different varieties of plants. At the present day there was an agricultural chemist in every province, and there were 160 experimental stations. In addition there were a great number of workers in agricultural science on the purely chemical side. It was with very great satisfaction that he could look back to-day and remember that within two years of his return home the first agricultural chemist had been sent out, namely, Dr. Leather, and his assistant, Mr. Collins. These gentlemen had been followed by Dr. Mann, who had done splendid work in the tea districts, and who had really put the whole industry on a chemical basis. Other men had followed since in the indigo and other industries.

He desired to put one point of very great importance to the author of the paper for his consideration. Was it likely that the Indian would develop in the line of original research? Would there be such a school as Prof. Thorpe had indicated, which would be recruited from India itself, and which would be able to dispense with the services of scientists from this country? He had put that question to those who had worked among the Indians, but he could not say that he had as yet any really satisfactory answer. Every one knew how capable the Indian was. Certainly he could not be "floored" in any examination; but the point was would he be able to take up research on his own account? There had been, and always would be, certain brilliant exceptions; but it seemed to him that the time was still distant yet when matters of research could be handed over entirely to the Indian himself.

Sir Robert Robertson, K.B.E., D.Sc., F.R.S., said it had been borne upon him during his stay in India that everything of importance for the chemical industry of explosives had been brought from a great distance. Ships had brought sodium nitrate from Chili, acetone from Canada, sulphur from Sicily, and glycerine and cotton from England. Those commodities had been worked up under the charge of Englishmen into cordite. Since then certain advances had been made in regard to Indian production. The importation of cotton waste had given place to the manufactuie of it in the mills in Bombay; and there were projects for the production of nitrates in the Ghats near that city. There were, therefore, evidences of progress, but at the same time there was an enormous field for development. He had also been struck with the difficulties which appeared to arise in regard to the exploitation of any particular Indian product. A product which would seem to be fairly easily prepared presented insuperable difficulties. In many cases the technique was known, but there were difficulties of transport, isolation, want of workers and so on. He agreed with Prof. Thorpe with regard to the necessity for seeing that men were trained in methods of research. It was after that that the difficulties seemed to him to become very great indeed, because they called into play the need for a class of man not plentiful even in this country—he referred to that class of man who had been thoroughly trained in physical chemistry, and who had in addition some knowledge of the treatment of constructive affairs. Such a class of man was in existence in Germany and played an important part in the exploitation of the German chemical industries. It would be some considerable time, he was afraid, before there were large numbers of such men in this country, and unless the Indian authorities made it very well worth the while of those men to go to India, such a scheme as that outlined by Prof. Thorpe would, he thought, come to a standstill.

The Chairman, in calling upon Prof. Thorpe to reply, said he would like to quote from memory the substance of one sentence in the Report of the Commission. In order to justify their proposal for an organised service for Chemistry and for other sciences in India, they quoted as an example the great results which had accrued from the good work done since the Government took the wise step in 1905 of founding a service for Scientific Agriculture;

Prof. Thorpe, in reply, said the question had been asked whether, in his opinion, it was possible for the Indian Universities to supply and recruit the service proposed in the paper. He thought it was. His experience was a limited one, between 20 and 30 Indian students having passed through his hands, but he thought there was no doubt that within a reasonable time, if the research schools developed, there was no reason why the service should not be self-contained from the Indian point of view. He had qualified his remark in the paper by saying that for some considerable period of time, doubtless, some home training in research would be essential for the men who would be capable of being recruited in the service.

With regard to chemical engineers, he regarded himself as a chemical engineer in the sense that he had been originally trained as an engineer and had ultimately become a chemist; but he did not think one could produce in the same man a good engineer and a good chemist. He did not know what Prof. Hinchley thought.

Prof. Hinchley said he was certain that one could.

Prof. Thorpe said that such a man would be almost as high as the angels. He was referring, of course, to a reasonable period of time. He dared say such a man could be produced if he was given ten years' training.

Prof. Hinchley said he thought such a man could be produced in a much shorter time if he was given facilities.

Prof. Thorpe said that if any remarks he had made had given any one the impression that he was

not fully conscious of the valuable work which had been done by the Institute of Science at Bangalore, he would desire that that impression should be removed at once, because the work done by that Institute was work of considerable importance. His point had been that the two things could not be combined in the same institution; one could not train men in the principles of research in the same institution in which one carried out organised commercial research such as he had suggested.

The meeting then terminated.

LA VIE INDUSTRIELLE EN FRANCE.

Les Travaux d'Agrandissement du Port du Havre.

Le port du Havre, point de départ principal de la navigation transatlantique française, a été l'objet, depuis une trentaine d'années, de grands travaux d'extension et d'amélioration. Après la création et l'aménagement de plusieurs bassins, on a décidé, par une loi du 11 février, 1909, la création d'un vaste bassin de marée conquis sur l'estuaire de la Seine, et précédé d'un nouvel avant-port entouré d'une digue. Dans ce bassin est prévu un nouveau quai de marée de 1,000 mètres de longueur, pour grands transatlantiques, et une forme de radoub de 312 mètres (1,023 ft.) de longueur.

Les travaux, interrompus pendant la guerre, ont été repris depuis, et les parties essentielles en sont achevées. Les digues en maçonnerie formant l'enceinte du bassin sont achevées, le quai de marée est en service sur la plus grande partie sa longueur, et la forme de radoub sera prochainement terminée.

Les digues limitant le bassin ont environ 4,000 mètres (4,375 yards) de longueur. Elles ont une hauteur totale d'environ 14 mètres et se composent d'enrochements de 3 grosseurs successives, surmontés de deux assises de blocs de béton, les premiers de 80 tonnes et les autres de 60 tonnes. Au-dessus se trouve un mur en maçonnerie.

Le quai de marée, destiné à l'accostage des grands transatlantiques, est terminé sur la moitié de sa longueur, sous la forme d'un mur plein. C'est un quai omnibus, permettant à marée basse l'accostage de navires de 12 mètres de tirant d'eau. Il a été fondé sur caissons perdus, foncés au moyen de l'air comprimé.

La seconde partie du quai de marée, dont la construction vient d'être entreprise, sera exécutée d'une façon à la fois plus hardie et plus économique. Ce quai sera porté sur des voûtes reposant sur de piliers espacés de 25 mètres (82 ft.) d'axe en axe, la hauteur totale étant de 29 m 50 (97 ft.) depuis la base de la fondation jusqu'au niveau du quai. Les piliers et les voûtes sont entièrement en béton, coulé dans des moules métalliques. Les pierres employées pour ce béton sont des galets de 2 à 10 centimètres (1 à 4 inches). Chaque pile est fondée sur un caisson métallique.

La forme de radoub est l'ouvrage le plus remarquable du port. Elle a 312 mètres de longueur (1,024 ft.) et 38 mètres (124 ft. 8 inches) de largeur. Elle vient donc immédiatement après celle de Liverpool (1,050 ft.) au point de vue de la longueur, mais celle-ci n'a que 120 ft. de largeur. On a d'ailleurs prévu son allongement de 50 mètres (164 ft.). Il est à noter qu'on achève, dans le port de Toulon (Méditerranée), une forme de 422 mètres (1,384 ft. 6 in.) de longueur.

Le procédé de construction employé pour l'établissement de la forme de radoub du Havre mérite d'être signalé. On a construit un immense caisson en acier, de 345 mètres (1,132 ft.) de longueur et 60 mètres (197 ft.) de largeur, dans une fouille protégée par des batardeaux. Une fois le caisson achevé et raidi par une certaine masse de béton, on a admis l'eau dans la fouille à marée haute, et on a amené par flottage la structure jusqu'à sa position définitive. On a continué le bétonnage pour noyer toute la charpente du caisson dans du béton, puis on l'a échoué à la profondeur prévue, après avoir déblayé le fond de la fouille au moyen d'injections d'air comprimé. Le fond et les côtés de la forme sont constitués, à l'intérieur du caisson, par d'épais revêtements en maçonnerie, d'une dizaine de mètres d'épaisseur totale.

La forme de radoub pourra servir, alternativement, de cale sèche et de bassin à flot. Elle est fermée au moyen d'un bateau-porte et d'une paire de portes busquées. Le bateau-porte a 40 mètres (131 ft.) de longueur, 8 m 50 (28 ft.) de largeur et 18 mètres (59 ft.) de hauteur.

On aura ainsi une idée de l'importance des travaux en voie d'achèvement au port du Havre par la masse de maçonnerie mise en œuvre; cette masse atteint 653,000 mètres cubes (854,000 cubic yards), en béton et maçonnerie, et l'entreprise a occupé jusqu'à 2,300 hommes.

L'Auto-Pompe d'Incendie Somua-Drouville.

Les Sapeurs-pompiers de Paris viennent d'adopter, pour renforcer leur matériel d'incendie, un nouveau modèle d'auto-pompe très puissant, construite par la Société Somua, et dont la pompe est du système Drouville.

Les ingénieurs qui ont étudié cet engin ont voulu fournir aux pompiers les moyens de combattre les incendies uniquement au moyen des réserves d'eau naturelles qui peuvent se trouver à une notable distance du lieu du sinistre: d'où la nécessité d'une pompe puissante, possédant un grand rayon d'action et, par suite, une vitesse élevée pour se rendre dans le minimum de temps sur le lieu de l'incendie.

En conséquence, le personnel qu'elle transporte doit être protégé efficacement, pendant ces longs trajets, contre les intempéries: sinon, par les temps froids ou pluvieux, les hommes se trouveraient dans de mauvaises conditions physiques au moment d'entrer en action et, après s'être dépensés dans la lutte contre le feu, ils seraient, pendant le retour, exposés à contracter de graves refroidissements: de là l'emploi d'une carrosserie fermée, à 8 places.

Le moteur à essence, de 80-90 h.p., sert successivement à la propulsion de la voiture et à la commande de la pompe. Celle-ci aspire par deux tubulures de 0 m 15 (6 in.) et refoule par six tubulures de 0 m 10 (4 in.) de diamètre.

Toutes les manœuvres relatives à la pompe sont faites d'un poste arrière, qui comprend les commandes suivantes: le levier d'embrayage, le levier de changement de vitesse, la commande des gaz du moteur, les appareils de contrôle du débit, etc.

Cette pompe peut débiter environ 300 m. cubes par heure (66,000 gallons), à la pression de 5 kilogr. par cent. carré (70 lbs. per sq. inch), et 135 m. cubes (29,500 gallons), à la pression de 12 kilogrammes (171 lbs. per sq. inch).

Le Salon de la Machine agricole à Paris, et les Essais de Tracteurs agricoles à gazogènes, à Essonnes.

Paris est toujours le siège des plus importantes manifestations relatives à l'agriculture et aux industries qui s'y rattachent. Plusieurs Expositions de ce genre y ont eu lieu cet hiver, notamment le Salon de la Machine Agricole, organisé par l'initiative privée avec l'appui du Ministère de l'Agriculture. Il a eu lieu au Grand Palais des Champs-Elysées, et a compté 475 exposants et 80,000 visiteurs payants, ce qui est un record par rapport aux années précédentes.

Parmi les machines françaises pour la préparation des terres, on remarquait le tracteur Citroën à chenilles souples Kégresse, du type bien connu qui a traversé le Sahara, ainsi que le tracteur Bauche, de 10 h.p., utilisable, soit comme tracteur véritable, soit comme charrue automobile. Citons également le treuil Joya, des Etablissements Agricultural, pour le labourage suivant le système roundabout, avec 2 câbles et 2 poulies de renvoi.

De sérieux efforts ont été faits pour adapter les moteurs à la marche au gas oil, ou, de préférence, au "gaz des forêts," c'est-à-dire au gaz pauvre produit sur place dans un gazogène portatif, au moyen de bois et de charbon de bois.

Quatre gazogènes de ce genre ont été essayés officiellement à Essonnes, près de Corbeil (Seine-et-Oise): ce sont les marques Etia, Vierzon, Lion et Autogaz, construites par des firmes françaises. En outre les Usines Renault, de Billancourt, ont également créé un gazogène qui n'a pas été essayé à ce moment, mais qui a été exposé au Salon, et qui comprend un épurateur de gaz très complet. Dans la pratique, il est nécessaire de faire démarrer le moteur à l'essence, pour faciliter la mise en route.

On attache, en France, beaucoup d'intérêt à cette question, car il se perd chaque année quelque 2 millions de tonnes de menus bois et déchets qui pourraient donner 500,000 tonnes de charbon de bois, utilisables dans les gazogènes fixes ou sur des automobiles à gazogènes, camions ou tracteurs agricoles.

Citons encore, comme machines intéressantes ayant figuré au Salon de Paris, les charrues brabants doubles des Etablissements Bajac, Huard, Savary, les treuils électriques de labourage de la Société générale agricole, les arracheuses de pommes de terre Mélichar, les arracheurs-décolleteurs de betteraves Degrémont, les matériels de vinification Mabille, Simon, Marmonier, etc.

TRADE OF CHINESE TURKESTAN WITH INDIA.

The annual report by H. M. Consul-General at Kashgar on the trade of Chinese Turkestan in 1922-23 draws attention to the lack of foresight and enterprise displayed by traders in regard to fostering and stimulating their markets. Instead, they have been inclined merely to import each year the commodities which fetched the best prices the year before, regardless of whether the market could stand it or not. This tendency has been the more regrettable in that the tremendous difficulty of the route via Ladakh and the limited amount of transport available render it particularly important to study the Hsinkiang market carefully and only import commodities which are both carriable with a minimum of deterioration and certain of a relatively unlimited market. The difficulties and dangers of the Karakoram route, are well known; suffice it to say that no other trade route in existence crosses such high passes or runs for so many weeks across mighty glaciers, through precipitous gorges and along breakneck ledges among some of the highest mountains in the world. The total number of ponies and camels plying on the route is estimated at 2,000; even if the carrying trade were in a healthy state this would not be nearly enough; as it is, however, most of the carriers are insolvent and entirely in the hands of the Hindus. The latter, shortsightedly, lend the carriers money on unfavourable terms and exact repayment in the shape of retransport of goods; the carriers who must get cash from somewhere to feed their animals, accept two or three times the amount of goods their ponies can carry and take it along the road in instalments, on what is known as the "dubko" system. This causes them to fail in carrying out their contracts within the specified time, whereupon they become liable for damages to the Hindus and thus still deeper in debt to the latter. The effect on the carrying trade, and therefore on the trade in commodities, is very bad, while certain Hindus profit individually by getting their consignments carried by their debtors at cheap rates, the carriers' ponies die like flies on the road from overloading and under-feeding, consignments are frequently left for months by the roadside, and the number of ponies available for the increasing trade steadily diminishes.

It would be a pity if an unrivalled opportunity for capturing the Hsinkiang market for some years to come were lost owing to disorganisation of the carrying trade on the main Indo-Central Asian route. Just before the Russian revolution the Tsarist Government was energetically developing the trade between Ferghana and Southern Hsin-

kiang, and bade fair to eliminate the Indian merchants altogether. With their railhead at Osh only eight days march from Kashgar and with only one pass to cross, the Russian traders had an enormous advantage over their Indian rivals, and this advantage was further increased by the establishment at Kashgar of a branch of the (State aided) Russo-Asiatic Bank. Now, however, all is changed; nothing comes from Russia but small driblets of Andijan silk and velvet from Tashkend; industry, trade and agriculture in Transcaspia are alike completely disorganized, to an extent which may be gauged from the fact that whereas before the Revolution Ferghana exported a quarter of a million tons of cotton to European Russia, now it has to import from Kashgaria what little cotton it can afford to pay for. As the trade with China Proper is on a small scale and is chiefly confined to commodities used by the Chinese, Kashgaria is obliged to depend on India for many quasi-necessaries such as cotton piece-goods, dyes, tea, sugar, etc., which formerly came from Russia. By stimulating the export trade of Hsinkiang, which is capable of considerable expansion, a much greater volume of imports could be paid for by exports than at present. Moreover, large profits are to be made by re-export of the above-mentioned commodities to Russian Turkestan which can still pay in gold, furs and jewellery for a limited quantity of such imports. Mention may be made of the route via Tashkurghan, the Baroghil Pass and Chitral, which during the last two or three years has been used to an increasing extent as an alternative to the Leh route by Indian traders.

ECONOMIC CONDITION OF HAYTI.

In his recent report on the economic and financial conditions of Hayti H. M. Consul and Chargé d'Affaires at Port-au-Prince states that Hayti stands to day upon the threshold of a new economic phase in its history. How far this will prove to be a phase of progress and prosperity will depend largely upon the realisation of the objects of the Haytian-American Convention of 1915. The old Hayti with its frequent revolutions has been replaced by a new Hayti where security of life and property is assured by a well-organised and disciplined gendarmerie. The stabilizing of Haytian currency on a gold basis in a fixed relation to the American dollar has banished currency speculation and inflation with their attendant ills, and has opened the way for legitimate commerce. The inhabitants are now free to devote themselves to agriculture and to develop and profit by their country's undoubted natural resources. It is generally agreed, however, that no great development is possible without irrigation work and improvements in the means of transport. This requires capital, and as there is no capital available in Hayti, it must be obtained from abroad, either by means of a foreign loan or foreign investment. If therefore Hayti desires development, it has no other choice but to encourage foreign co-operation by guaranteeing to intending foreign investors equal opportunities with its citizens before the law and legal facilities for the ownership of land for *bona fide* agricultural, industrial, and commercial enterprises.

GENERAL NOTES.

Early Chinese Sculpture.—The Victoria and Albert Museum has acquired a magnificent life-size Chinese statue in dark grey limestone. The figure represents the Buddha Amida seated cross-legged. Behind the head is a large circular halo, decorated with elaborate floral designs of a type derived from Indian Gupta sculpture, retaining considerable traces of colour on the surface of the stone. The statue, which is a characteristic example of the great Buddhist art of the T'ang dynasty (618-906 A.D.), is probably the finest piece of Chinese stone sculpture that has yet reached this country. It is temporarily exhibited on the staircase leading to Room 62, just to the right of the main entrance.

Industrial Disputes.—From a statement made in Parliament on behalf of the Ministry of Labour it appears that the working days lost through industrial disputes in Great Britain and Northern Ireland in 1919, 1920, 1921, 1922, and 1923 numbered, approximately, 35 millions, 26½ millions, 86 millions, 20 millions, and 10½ millions, respectively. For the months of January and February, 1924, the corresponding figure was over 1,300,000. The foregoing figures relate only to days lost at the establishments where the disputes occurred, and no figures are available as to days lost at other establishments. Disputes involving less than 10 workpeople, and those lasting less than one day are not included in these figures, unless the aggregate duration (*i.e.*, the number of workpeople involved multiplied by the number of working days) exceeds 100 days.

MEETINGS OF THE SOCIETY.

Indian Section.

Monday June 30, at 4.30 o'clock.—J. C. French, I.C.S. "The Art of the Pāl Empire in Bengal." The Right Hon. the Earl of Ronaldshay, G.C.S.I., G.C.I.E., will preside.

Dominions and Colonies Section.

Monday, June 16, at 4.30 o'clock.—C. V. Corless, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada." Sir Richard Redmayne, K.C.B., M.Sc., M.Inst.C.E., M.I.M.E., M.I.M.M., F.G.S., Chairman Governor, Imperial Resources Bureau, will preside.

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FRIDAY, JUNE 13, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2).

NOTICES.

NEXT WEEK.

MONDAY, 16th JUNE, at 4.30 p.m. (Dominions and Colonies Section.) C. V. CORLESS, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada." SIR RICHARD REDMAYNE, K.C.B., M.Sc., M.Inst.C.E., M.I.M.E., M.I.M.M., F.G.S., Chairman-Governor of the Imperial Resources Bureau, will preside.

DOMINIONS AND COLONIES SECTION.

MONDAY, 2nd JUNE, 1924. RT. HON. VISCOUNT MILNER, K.G., G.C.B., G.C.M.G., in the Chair.

A paper on "The Mandate System and the British Mandates," was read by The Rt. Hon. SIR FREDERICK LUGARD, British Member of the Permanent Mandates Commission, League of Nations.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

EXTRA MEETING.

MONDAY, MAY 5TH, 1924.

SIR HERBERT JACKSON, K.B.E., F.R.S., in the Chair.

The paper read was :—

PHOTOGRAPHY IN SCIENCE, INDUSTRY AND MEDICINE.

By T. THORNE BAKER, F.R.P.S.

(Director of Research, Imperial Dry Plate Co. Ltd., Research Laboratories).

The attempts of early experimenters to "fix" the ephemeral image of the camera obscura were undoubtedly actuated by motives of art; the possibility of such an accomplishment having vast scientific applications was certainly never foreseen in those early days, and I doubt if to-day more than an insignificant fraction of the general public realizes how this great science is wrapt up with their everyday life.

Photography may be said to have passed through four great stages. The first embraced the hopes and the theories and attempts of men to imprison the image of the camera obscura, from the time of its description by Leonardo da Vinci to the early work of Niépce. The silhouette and positive impressions on metals represented a second stage, which might be said to have continued in its gradual development throughout the early days of the wet plate. The dry plate, due to the historic work of Dr. Maddox and others of that time, introduced a third phase which saw slow, but astonishing development. The fourth stage, in which we find it to-day, began when trained scientific men began to concentrate their attention and research upon not only the understanding of the photographic processes in use, but upon their possible applications to various branches of commercial and scientific work. In this stage there was, of course, the discovery of the X-rays in 1896, which has been responsible for photography playing an enormous part in medical work, and more recently in the solution of some of the most vital problems of physical chemistry.

It would be quite impossible within the limits of a single lecture to give any detailed account of the very large number of industries which at the present time are either directly or indirectly dependent on photography, but I hope to be able to present a few selected instances of general interest in which this great science is playing a part.

We might, with advantage, devote a few moments to consider what, in the art itself, has contributed to its present high state of efficiency. We know for example, that photographs can be obtained with a ten-millionth part of a second's exposure; that the aeroplane surveyor can take photographs through mist of landscapes almost invisible to the eye; that a microbe, a twenty-five thousandth of an inch long can be magnified two hundred million times in

area and that its photograph produced in ultra-violet light will reveal a remarkable amount of that exquisite structure on Nature's part that the eye of man will never see unaided. We can make sensitive plates or films which vary in speed by a thousand times, and turn them out with surprising uniformity and mechanical perfection.

In other words, the plate chemist has learnt the secret of the sensitiveness to light of silver bromide; he can produce an emulsion in gelatin of this unique substance which shall have a predetermined size of grain, of contrast giving power and rapidity. He can make it sensitive to all the colours of the spectrum, to the invisible infra-red and ultra-violet rays, to the X-rays and shortest wave motions produced by radium.

The progress of photography has been largely due to the extension of the colour-sensitiveness of the photographic plate. The slide on the screen shows a photograph in natural colours of the spectrum of arc light produced by the diffraction grating.

In this familiar spectrum we see, roughly speaking, three regions of colour—blue, green and red. The light of those colours is caused by wave-motions in the ether which vary in wave-length from 4 ten thousandths of a millimetre to 7 ten-thousandths of a millimetre, from crest and crest as it were. Photographers dealt for years mainly with these visible colours of which only the violet and blue affect an ordinary plate, and twenty years' continual labour was devoted to making silver bromide more sensitive to the green, yellow and red rays. But let us see now in the next slide, the enormously increased range of wave-lengths with which we deal to-day; it is this extension in range with which photographic progress is so intimately associated. Here we find radiations of wave-length as short as one ten-thousandth of a millimetre only, the shortest characteristic radiations excited by X-rays in the elements, ranging through that region, recently discovered, where the X-rays themselves begin to overlap, or merge into the ultra-violet, and extending from the ultra-violet through the visible and infra-red spectrum to the waves that we know as heat, and—still further on—as "wireless." Thus the wonderful range of colour which nature has allowed the human eye to see is only a mere fraction of the vast range of wave-lengths to which the photographic plate is susceptible, which extends from less than one Ångström unit to a wave-length of at least 50,000 A.U.

The photography of the ultra-violet has proved of the utmost importance; it has perhaps even paved the way to the production of the food and power on which future generations will depend. Take as an example the production by means of light of synthetic formaldehyde and sugar, with which the names of Dr. Moore and Professor E. C. C. Baly are intimately associated. Under the stimulus of ultra-violet rays of certain wave-lengths the waste gas of the atmosphere—carbon dioxide—will react with water to give formaldehyde which is further converted into reducing sugars. The measurement of wave-lengths chosen must be done with the aid of photography, which has thus directly assisted Prof. Baly and his colleagues to probe the secret of vegetable life and to reproduce in the laboratory the actual life processes of plants. One has only to carry the work further and to produce on a commercial scale starches and sugars which on fermentation can be converted into alcohol, and the production of power from the enormous quantities of waste gases in the atmosphere becomes a thing of possibility.

There is an old story of Bunsen and Kirchhoff looking at a fire at Mannheim through an early spectroscope, in which quantities of strontium had imparted to the flames a characteristic red colour. The philosophers were made to wonder whether it might be possible to recognize a substance by the nature of the light emitted at far greater distances. As we know, spectro-photography has since those early days not only told us the nature of the constitution of the sun and of immense numbers of stars but has enabled us to calculate the velocity of celestial bodies and has opened up an inexhaustible pathway into the unknown, while spectrum analysis by photography has reached a state of extraordinary precision, and has become widely adopted in the laboratories of both research and industry.

If the light from an electric arc or spark be examined with the spectroscope, superimposed over a more or less even band of colour are bright lines, due to radiations caused by the change of orbit of the electrons revolving round the positive nuclei of the

atoms. The slide on the screen shows a photograph of the electric arc, the poles of which have been brushed with a solution of lithium chloride. In modern forms of spectroscopic cameras, or spectrographs, the ultra-violet region is usually included with the visible region, and a scale of wave-lengths is photographed on each negative contiguous to the spectrum, so that the principal lines can be easily identified. Such a camera is seen in the next slide, while we next see three spark spectra, the oscillatory spark discharge taking place between electrodes of aluminium, iron and tungsten.

As a means of rapid chemical analysis by measuring the wave-lengths of the principal lines, the spectrograph is unique, especially as it indicates such excessively minute quantities. The constituents of London tap water can be identified from a single drop of the water placed on the electrodes of the spark gap, though it contains only the three thousandth part of a grain of solid matter. Minute traces of zinc in the venom of the cobra have been detected in a similar way, minute quantities of nickel in fats, traces of mercury in explosives, and so on.

A great deal of information has been obtained in the realms of organic chemistry by photographing the shape of the absorption curves of substances, particularly in the ultra-violet region. Examples of visible colour change are seen in the two next slides. These are spectrograms taken with a neutral grey wedge placed in front of the spectroscope slit—this has the effect of producing an image at any point along the spectrum corresponding to the degree of transparence of the substance under examination. Thymol blue, for instance, is ordinarily a yellow dye, the absorption curve of which is now seen; a minute trace of alkali turns the dye indicator pink, when its colour as analysed by the spectrograph appears as seen in the lower spectrogram. The next slide shows a similar change in bromo-cresol purple.

Where the "colour" is invisible, that is to say, the absorption band is in the ultra-violet, it may be measured in various ways with the ultra-violet spectrograph. I will show one typical example made by Dr. Judd Lewis, who has already described his methods before the Society. The result of these series of exposures is to obtain data which give the shape of the absorption curve of a solution and the study of these characteristic shapes has given an immense amount of new information to the organic chemist and to the physicist.

In the case of a line spectrum, in which the relative brightness or intensity of the various lines is different, the neutral wedge has been recently used to measure photographically the comparative strength of the lines.

The effect of photographing a line spectrum through the wedge is seen here, and you will notice that the stronger lines are of greater height. This height does not depend on the brightness of the lines only, but upon the characteristics of the photographic plate used; Professors Nicholson and Merton have done some valuable work on the intensity and distribution of spectrum lines in this way.

Another instance of the applications of spectro-photography may be seen in a series of photographs of a wireless transmitter spark; here we see that a change in wave-length caused by tuning with inductance alters the characteristics of the spectrum in an entirely different manner from that caused by tuning with capacity. The wave-length of the wireless radiation or spark frequency is exactly the same in the case of the two lower spectrograms, yet the character of the lines is entirely different.

You will thus see that the photography of the spectrum has many fields of application. They are, indeed, so numerous that it is impossible to give more than a few indications of them in the time at our disposal.

A short account of some of the modern research work on photographic chemistry becomes necessary here to show how diverse characters of plates can be prepared to deal with the varied subjects which I shall briefly refer to presently.

The sensitive film of a photographic plate is prepared by emulsifying silver bromide in gelatin. The precipitate at first formed consists of minute crystals of silver bromide. These crystals are too small to be seen as such even at a magnification of ten or fifteen thousand diameters. They rapidly increase in size, however, when they are seen to consist chiefly of flat triangles and hexagons. We shall see in the next three slides this progress of growth. The first shows the silver bromide at an early stage; the second at a later stage; the third shows the grains of the fastest plates yet made.

Now the general difference between the slow plate used for photo-mechanical reproduction and the rapid plate used for recording purposes, lies in the difference in crystal dimensions. As we have seen the size and sensitivity of the grains can to-day be controlled with remarkable accuracy, so that the plate maker is able to produce—for various purposes—a wide range of plates varying a thousand times in speed, and at least ten times in density-giving power.

We can, as you know, render the plate, ordinarily sensitive to blue-violet rays alone, sensitive to various parts of the spectrum—to green, yellow, red, infra-red or ultra-violet. This is done in the case of visible colours and the infra-red by means of dyes, which make the silver salt absorb the rays required to affect the plate, and in the case of the ultra-violet and X-rays by modifying certain physical characteristics of the emulsion, which presumably has the same effect.

The next slide shows three types of plate—the ordinary one, sensitive to blue-violet, and two types of so-called panchromatic plate which are affected by rays throughout the entire visible spectrum. Photography in the extreme ultra-violet is a more difficult problem, as the gelatin vehicle used to carry the silver bromide is strongly absorbent. Plates are, however, made commercially which will record admirably up to 1,800 A.U., and much valuable work has been done with them. A great deal of attention has been devoted to plates specially sensitive to X-rays, and, as we shall see later, they have played an important part in radiographic progress.

There are other matters to be considered in scientific work. The size of grain has often to be exceedingly small in order to obtain sufficient resolving power. One of my colleagues in the Imperial Dry-Plate Research laboratory, Mr. L. F. Davidson, has recently obtained photographs of the silver bromide crystals in the actual progress of development, at a magnification of 15,000 diameters, and those have shown that, under certain conditions, the exposed crystals burst during the process of reduction, and throw off "shoots" whereby they join up with adjacent crystals and form large grains which entirely prevent the fine definition required for certain classes of work. An agglomerate grain composed of crystals which, on development, have joined up by extrusion, is seen in the slide now on the screen.

A vast amount of fresh information regarding the sensitive film, its preparation and its behaviour, has been gleaned during the past three or four years, a large proportion of which has been due to the application to photography of *itself* in the form of high-power photo-micrography. This brings us to the field of miscroscope work, in which photography to-day plays so eminent a part.

At a symposium of the Faraday Society held in September, 1920, dealing with the microscope, Mr. S. Whyte set forth in a few words some of the uses of miscroscope in engineering works; by its means inherent defects in steel are discovered; troubles arising through bad ingot pouring, faults arising in the forging or stamping of steel, and so on, are detected with its help. In fact the microscope, with its auxiliary, the camera, is to-day an essential part of the average engineering works equipment.

On the occasion of this meeting, Sir Robert Hadfield suggested that one of the objects we ought to have in view should be to obtain increased knowledge from examination at *higher* magnifications, that is to say, 5,000, 8,000 and still higher.

That was less than four years ago. A few weeks ago a photo-micrographic apparatus, designed by Mr. N. P. Chopra, was announced, which permits of magnifications of 25,000 diameters or more—over 600,000,000 times in square measure. By Mr. Chopra's courtesy I am able to show two photographs of his apparatus and one or two specimens of his high-power magnification work.

An interesting industrial use of the microscope, employed in rather a novel manner, is illustrated in the next slide. Here we see two photo-micrographs taken of thin sections of wood, which is being aged or seasoned by a new process that is giving excellent results in about 9 days against several months or even years. A long series of these photographs were taken at intervals of ten minutes, and were then printed on cinematograph film and projected as a motion picture. Projected at the rate of sixteen pictures a second, the whole nine days' process of seasoning is seen within 81 seconds. Many industrial processes are being dealt with in this way, and, as you can understand, the advantage of watching a slow chemical or physical

process take place at high-speed is of the utmost value.

Opposite to such a process is the *slow* motion picture, which analyses an action too rapid for the eye to follow, so that it can be followed at leisure. Photographs are taken for this purpose at the rate of 140 a second, sometimes more, and are reproduced at the usual rate of sixteen a second. A movement which actually lasts a tenth of a second thus appears to have a duration of nearly a whole second. The application of this type of photography has been found of considerable value in certain industries, where men or women are engaged in some manual operation requiring dexterity. The output of one worker may be much lower than that of another, due to some lack of skill in manipulation. By taking a slow motion photograph of the operator at work, the reason of this lack of dexterity is usually revealed and can be made good.

Messrs. Pathé have very kindly prepared a new film of this type for me to show to-night. It is preceded by a short slow-motion picture of animals jumping; the industrial picture shows rivetters at work in a shipbuilding yard.

A good deal of work is being done on the slow-motion camera to-day. In order to take pictures at the rate of 128 a second, the actual exposure must only be 1/272nd of a second, and in the Bell and Howell ultra-rapid mechanism the weight of the moving vane or shuttle which regulates the exposure has been reduced in weight to 70 grains. A flexible shaft enables the mechanism to be driven by a handle some distance away from the camera, so that all vibration is avoided, although the peripheral speed of the main shutter is several miles a minute.

The speed of recording is very much greater than this in the case of rapid cinematography, and photographs have been secured as many as 5,000 per second for scientific research.

These photographs are of quite a different type to those which have solved certain physical problems, of which Prof. Boys' pictures of the flight of bullets and Prof. Worthington's records of the initial stages of splashes, and so on, are examples. The actual exposure given in some of these cases has been that of the spark discharge of a Leyden jar, lasting less than one millionth of a second. Prof. Boys actually reduced his exposures to the ten-millionth part of a second in photographing rifle bullets travelling at the rate of 1,000 miles an hour.

The fact that a light impact lasting one ten-millionth part of a second can so alter the sensitive grains of a photographic emulsion as to render them developable brings us to the modern ultra-rapid plate which is constantly finding more further practical applications.

The preparation of the "fastest" plates depends, to a large extent, on the purpose for which they are required. The action of light, presumably in causing an emission of electrons by photo-electric effect, can only take place when light energy is absorbed. It is thus necessary in dealing with ultra-violet light to use a silver bromide emulsion the opacity of which to ultra-violet is a maximum, but care has to be taken also that the grains of silver bromide have reached their maximum sensitivity irrespective of their selective absorption.

Plates specially sensitive to ultra-violet have recently been used for ordinary photography with a new lens I have designed, made with quartz, corrected by a component lens also transparent to ultra-violet. With such a combination it is possible to reduce the time necessary to take a photograph to one fifth of that required at present; modern plates of a speed of 600 H. & D., thus have the effect of a speed of 3,000 H. & D., and some entirely new possibilities may be opened up in this way. As an instance of what may be done in just an ordinary way I will show a snapshot taken with this lens in an ordinary room lighted merely by a couple of incandescent gas burners.

A most important commercial application of the very sensitive plate has been recently developed in aerial survey work. During the war a great deal of thought and experiment was concentrated on the problem of photography from the air, and immediately afterwards the methods that had been so successfully worked out were applied to practical peace-time purposes. Much of the map-making and survey work of the future will be done by aerial photography; it is finding extensive use in the survey of ground for road transport, and for recording the development of the land by railways, for studying the congestion of harbours and aiding the architect in factory construction. This year entirely new applications are to be made. One of these is to illustrate, for the education of children, various geographical

terms which are not easy to visualize in the ordinary way, such as delta, miasma, meander and so on; no geography book could possibly give the student the admirable grasp of the significance of such terms which is given by the birdseye view of the aerial photograph. Another is to illustrate for science students the works process as it exists, and not as the present-day text-book has usually to describe it with entirely inadequate sketches and plans.

We can perhaps get a better idea of the potentialities of this branch of photography by briefly studying a few actual examples, which have been kindly lent me by Messrs. Aerofilms, Ltd., of the London Aerodrome, Hendon.

Great assistance has been given to aerial photography by the advances made in sensitizing plates for the green and red rays, which enables the use of a yellow or red colour screen in front of the lens to cut out the large amount of ultra-violet and blue rays reflected from the particles of atmospheric haze and so to secure clear definition.

Let us turn now from the recording of such extensive subjects to the more delicate, but equally important uses of photography in electrical and physical science.

As a first instance we might take the oscillograph—an electrical instrument which responds to minute currents and causes the fine wires placed in a magnetic field to become displaced, a tiny mirror attached to the wires throwing a spot of light on to a travelling photographic film, so that it can record actual wave-forms of electric currents and other vibratory systems. Another form of instrument is the Einthoven galvanometer, which we see on the screen; a silvered quartz fibre is placed in the magnetic field, and it is used as a minute shutter which stops the passage of a pencil of light directed upon a falling plate, placed in the apparatus you see here. The change of potential caused by muscular contraction is made to influence the galvanometer, and the movements due to the currents are recorded on the plate. Electrodes are placed upon the skin of the patient, three so-called "leads" being recorded, from right arm to left arm, right arm to left leg and left arm to left leg. Such a record you now see, as made with the Cambridge and Paul cardiograph. This is of the normal heart; the next slide shows a case of auricular flutter, the next a record of a dog under an anæsthetic, and in the next slide we see a cardiograph recorded in a consulting room half-a-mile away from the patient, the currents being transmitted over the ordinary telephone line.. The examination of a patient by joint telegraphy and photography opens up rather an astonishing field of possibility!

The Einthoven galvanometer was used more than ten years ago to record wireless messages upon a travelling band of photographic paper. As may be imagined, the photographic recording of these electrical instruments has very numerous applications, far more than one could deal with on the present occasion.

A recent innovation in this direction is worthy of mention; it is Mr. J. H. Powell's radium capsule,* used as a very sensitive recorder where there is very little power to operate the recording mechanism; instead of using a recording pen or stylus to trace a record, a small brass capsule is fitted to the moving part, at the closed end of which is a small speck of radio-active material; at the opposite extremity a small aperture allows the radiations to fall in a parallel beam upon photographic paper.

Another instance of photographic recording is the sonometer recently devised by Professor Low, a diagram of which you now see. A pencil of light is deflected by a diaphragm which is vibrated in accordance with the sounds impinging on it, and a fine spot of light makes its record upon a moving plate or band of sensitive paper. The definition is very fine indeed, as can be gathered from the results we shall now see.

This instrument has wider applications than the analysis of vocal and musical sounds; it can be used in engineering work for such purposes as testing periodic errors in geared machinery, and has indeed been called the "stethoscope" of the engineer.

High-speed plates are, of course, essential for much astronomical and meteorological work. Through the courtesy of Mr. Dobson I am able to show two excellent records of meteors in flight, taken on extremely rapid plates which have been slightly fogged by preliminary exposure to light in order to overcome the inertia of the sensitive emulsion.

If we look at the curve connecting exposure with density in a photographic negative, we see that there is a period of exposure

* Journal of Scientific Instruments, I, vii., 205.

during which a minimum amount of light has no effect, and that for the first active period of the exposure the density obtained is insignificant. After this period, additional exposure gives rise to a more or less steady increase in density. The plate is sufficiently light-fogged just to overcome this inertia period. Then any additional light from the meteor will be added to this effect, and on development it will be recorded by useful density. Professor Lindermann and Mr. Dobson utilized this effect with marked success, and found that the star track came out clearest when the fogging could just be seen.

To effect a measurement of the height of meteors, two similar cameras were set up 5 kilometres apart pointing to the zenith, and oriented so that the edges of the plates were parallel to the base line.

The necessity of changing the plates by hand throughout the night was avoided by means of an automatic changing device controlled by electric contacts in a lock. The camera could be opened and shut at any pre-arranged time as the wheel of the focal plane shutter was provided with two stops which engaged with the armatures of two electro-magnets.

To obtain the speed of a meteor, a revolving sector driven at a constant speed was fixed over the lens of one camera; by this means the track of a meteor is seen to be broken at regular intervals, and in this way the velocity can be measured.

The slides show two photographs of an unusually bright meteor; the track was so long that neither the beginning nor the end is on the plate. The height when it passed overhead was 83½ km., and its velocity 35½ km., per second.

A further interesting example of the uses of extreme speed plates is for the study of various industrial conditions of working, about which much more information is being demanded by those interested in industrial hygiene. I will show a couple of photographs taken under very adverse conditions of lighting, recently obtained in coal mines. Such photographs have been almost impossible to obtain until the recent advance in the speed of plates was achieved a year or two ago.

The slide now on the screen shows an example of the application of photography to radioactive phenomena. It shows the bombardment of a nucleus of an atom by an alpha particle of radium and illustrates the actual breaking off of a hydrogen atom and thus shows the transmutation of an element. It was the first successful photograph abtained of an end-on collision after 21,000 attempts.

A branch of photographic work that is attracting some attention just now is the telegraphic transmission of pictures. It is not long since you had at this Society M. Edouard Belin, the French inventor, who has devoted a great deal of time since about 1904 to this fascinating subject. He showed some remarkably good results of photographs transmitted by his apparatus and I hardly think I need enlarge on the merits of his system on this occasion. It was Professor Korn who really inaugurated commercial photo-telegraphy, in 1907, with his selenium apparatus, with which many portraits were telegraphed from both Paris and Manchester to the Daily Mirror office in London, and were published in that newspaper. This was followed subsequently with an apparatus of my own, which was in constant daily use for upwards of two years, and as far back as 1912 I showed, at the Royal Institution, an experimental picture sent by wireless with this apparatus, in the days before the modern valve had been developed.

I think a great many people must have wondered why these familiar telegraphic pictures suddenly ceased to appear. The truth is that the cost of a long distance telegraph or telephone line had proved altogether prohibitive. I hope that before very long a new system will be at work, on a really commercial scale, in which the time of transmission, by either metallic line or wireless, has been reduced to 2½ minutes; the system is entirely automatic, and for wireless work the difficult problem of synchronising the sending and receiving instruments has been entirely eliminated; I cannot unfortunately, say more about it at the moment.

An example of a telegraphed photograph is seen on the screen which was transmitted from Manchester to London on a metallic circuit.

I do not propose this evening to touch on the very important matter of general illustration. That the photographic process is involved in practically every printed illustration in the world's peridicals is well-known. There are new methods of printing which are rapidly developing—rotary lithographic, offset and rotagravure,

which make it possible to produce really high-class illustrations on the cheapest of papers at a remarkable rate. It would be impossible to attempt to do justice to any one of these processes on the present occasion, but I should like to point out how much recent photographic progress has contributed to their success. A great deal of most valuable research has been carried out by Mr. A. J. Bull and his colleagues, at the Bolt Court School of Photo-engraving, and the art of half-tone engraving and photogravure has been reduced very much to an exact science instead of remaining as it was a few years ago, a matter more or less of individual skill guided by intuition and long experience.

Photo-engraving is one of the greatest and one of the most successful applications of photography, and it is one which touches every one of us to-day, as a world devoid of illustrations would render modern business impossible and would indeed be unimaginable.

We come finally to the field of X-rays, in which photography has not only developed a science that has proved of the utmost benefit to humanity, but has assisted the physicist to carry on investigations that have enabled him to reorganize and greatly to extend our knowledge and conceptions of matter. We can claim for photography that it discovered radio-activity; we can equally claim for it that it has definitely established the lines on which Nature's architecture is based.

As far as the medical side is concerned, we have only to look back to 1896 to remember the crude early radiographs that were taken, when the exposure necessary to obtain an X-ray photograph of the hand might extend to several minutes. Very rapid progress was made, and even during the South African war the extraordinary value of the X-rays was proved. It gradually became apparent that X-ray photographs would not only reveal swallowed coins, bullets and the position of fractured bones, but that muscles and tendons "showed up" as well. Then came the knowledge that by suitably choosing the penetrating power of the rays it was possible to differentiate between organs of the body of different opacity. To-day, the early signs of tuberculosis can be seen in a good radiograph of the lungs, with so much success that the miners of the Witwatersrand are examined monthly by X-ray photography, and on this examination of their lungs depends their permission to continue at work in the mines.

By taking a "meal" of some harmless, but opaque substance, such as barium sulphate or bismuth carbonate, a series of photographs taken at intervals can be obtained, showing the whole of the alimentary tract, and just recently by the injection of lipiodol, photographs have been taken showing the circulatory system of the chest and the bronchial passage with exquisite detail. A good idea of this new technique is seen in the two photographs on the screen. The first radiograph is an ordinary one, the second is of the same subject after the injection of lipiodol.

The great progress of X-ray work has been due as much to electrical progress as to advances in photographic technique, but some tribute is due to the great perfection which has been attained in the preparation of plates specially sensitive to the rays, and to the so-called intensifying screens which enable a reduction of nearly ninety-five per cent. to be made in the exposure. The effect of one of these screens is seen in the next slide; a piece of intensifying screen is laid half across the plate, and you will see how its effect is to provide far more detail for a given exposure.

These screens are of great value in taking photographs of internal organs (such as the stomach, after a barium meal) where the finest detail is not required.

Such powerful apparatus is made to-day that even where definition is of paramount importance, exposures can be made in a small fraction of a second. The slide on the screen shows a snapshot of a heart taken in the thousandth part of a second by means of an apparatus known as the "single-flash."

The immense progress in radiography made in *recent* years is very largely due to the brilliant invention of the Coolidge tube. Dr. Coolidge devised an X-ray tube in which the power and penetrating qualities of the rays can be controlled so completely that a standardisation of the beam may be attained which was conspicuously lacking in all previous apparatus.

By the courtesy of Mr. Geoffrey Pearce, of Messrs. Watson & Sons (Electro-Medical), Ltd., I am able to show a very modern portable equipment provided with what is known as a "Baby Coolidge" tube. You will see that when a local current is applied

to the cathode, a small tungsten spiral on its surface becomes incandescent. This spiral throws out a stream of electrons the number of which controls the resistance of the space between the cathode and the anode. The tube is exhausted to about a thousand-millionth of an atmosphere, and its resistance is so great that no current will pass through it until the electron stream makes a passage. By varying the degree of incandescence of the filament, the resistance of the tube is lowered and a heavier current can be passed.

A great advantage of the Coolidge tube is that with it excessively soft rays can be produced, so soft indeed that the delicate structure of cherry blossom and similar objects has been radiographed, while on the other hand the rays can be made at will so highly penetrating that the new science of radio-metallography has been established. The penetration, in fact, has been found to be a function of the voltage which is applied to the tube terminals, and while with a pressure of fifty or sixty thousand volts we can penetrate the human body, with 120,000 to 200,000 volts we can photograph *through* a solid steel casting two inches in thickness.

As an example of the use of soft rays, I will show first a cheap briar pipe made of inferior wood, the holes of which have been filled with putty. This radiograph suggests to all smokers the expediency of having a pipe X-rayed before buying it!

I have one or two other examples of aluminium welds, a faulty aeroplane magneto and a casting of inferior alloy, which we will glance at briefly.

An indication of the value of this branch of radiography in industrial research may be gathered from some interesting specimens which Sir Robert Hadfield has kindly lent me to show to-night. These are radiographs taken of large carbon electrodes as used in electric furnaces. The first three show radiographs of the raw materials used—retort carbon, pitch and anthracite. The two next slides show, first, an electrode in which distinct structure is visible, and second, a graphite electrode devoid of structure yet manufactured from the same three raw materials.

We come finally to the still newer phase of X-ray photography, the analysis of crystal structure and X-ray spectrography. So much work has been published by Sir William Bragg, his son and their colleagues, on this subject, and you have so recently had an admirable lecture at this Society on crystal structure, that I need do no more than make a general reference to the subject as being yet a further application of photography to scientific research.

Under suitable conditions we can produce a spectrum of the very short wave-length radiations of X-rays, just as we produce—with the far coarser dispersing medium of the prism or diffraction grating—a spectrum of white light.

The most practical application of this work lies, perhaps, in the power of crystals to disperse the rays in the manner of a diffraction grating In any crystal the atoms and molecules are arranged according to a definite system, and the atoms of the same element are all arranged so as to occupy the points of the space lattices. The planes of atoms act as diffracting surfaces and if a very narrow beam of rays be directed upon a small tube of a crystalline substance, the diffracted rays will form lines at intervals regularly spaced according to the crystal structure, and these lines can be recorded upon a photographic plate placed behind the tube. As each line is at a distance from the centre of the plate dependent on the distance between the planes of atoms in the crystal, there is one line for every important set of planes in the crystal. Hence substances with different crystalline structure give entirely different patterns. By developing this technique new methods of chemical analysis have become possible which are likely to prove of the greatest advantage in the technical laboratory.

Sir William Bragg has very kindly lent me some examples of his recent work to show you to-night, representing the crystal structure of phthalic acid, naphthalene and other substances. Some of this work has already found practical application in the industries, and while no-one can, as yet, tell quite where it will lead, it is certain that this branch of photography has already provided an enormous amount of new knowledge.

We find the analytical uses of the X-rays applied in many directions. Thus only recently Prof. Sebelien* described how at the Norwegian Agricultural Institute, he had analysed by crystal structure samples of ancient bronzes, including the bronze bands from the gates of Shalmaneser II.,

*British Association Paper, Section H, 1923.

which are now in the British Museum. Various objects belonging to the earliest dynasties were found to be of very pure copper, without any trace of tin, whereas objects from a later period were found to be real tin bronzes of normal composition.

In conclusion, I feel that it is necessary to make something in the way of an apology to you for dealing in so brief a manner with many subjects which are deserving of the fullest study. But the main object of this lecture has been to attempt to indicate what a vast field is covered to-day by photography, and the very fact that we have had to pass so many subjects so rapidly under review is really the best testimony to the usefulness of the photographic process.

DISCUSSION.

Colonel C. N. Simpson, D.S.O., R.F.A., asked the author if barium was superior to bismuth for taking X-ray photographs.

Mr. Thorne Baker replied that bismuth was now practically obsolete, because barium was so very much cheaper, and also the effect was rather better with barium than with bismuth.

Dr. G. H. Rodman desired to congratulate the author upon having brought to their notice a very interesting description of modern photographic processes. It had been his lot for many years to be associated more or less in different directions with the use and application of the photographic plate for scientific research. The Chairman remembered, probably, as well as he himself did, the first occasion on which Mr. Campbell Swinton had made an X-ray exposure upon his own hand at the London Camera Club. That was the first exposure in which a photographic plate had been impressed by the Röntgen rays in public. That result, he was glad to say, was likely to remain on view, seeing that it was printed in a permanent process, and could be seen in the Museum of the Royal Photographic Society. On that occasion, if his memory served him rightly, it had been necessary to give an exposure of 18 to 20 minutes through an aluminium plate, with the idea of screening off certain of the rays which were not considered at that time necessary for photographic purposes. When one came to consider that an eminently more satisfactory result was obtained at the present time in as short a period as that mentioned by the lecturer, namely, something like one-thousandth of a second, by a single flash, that in itself spoke for the progress which the science of radiography had made, aided, as it had been, by the work of the photographic chemist, who had produced not only extremely rapid emulsions, but by the use of intensifying screens with which the exposure was reduced by something like 95 per cent.

The illustrations of the photography of metal surfaces which had been shown on the screen were, to his mind, some of the best work which had been exhibited. Those surfaces of metal were, in his opinion, extremely fine examples of the application of photography for the recording of metal structure.

The author might have stated that, even in the world of art, the X-ray and the photographic plate had come to the service of scientists and investigators. By means of the application of radiography, as had been shown by Prof. Heilbron, of Amsterdam, some years ago, it was possible to discriminate between a faked oil painting and one which was unfaked, and by this he meant any old picture which had had subsequently added to it a super-imposed image of modern day production. This could be readily disclosed by the X-rays which were intercepted to a much greater extent by the lead containing pigment of the original painting than was the case by the material used in the later addition. The aniline dyes and colours such as those employed at the present time had very little resist as compared with the metallic material used in the old day paintings.

The Chairman, in moving a very hearty vote of thanks to the author for his paper, said the Royal Society of Arts was to be congratulated on being able to publish in its *Journal* such a complete and informative account of the applications of photography. Mr. Thorne Baker's name was known to all in the photographic world. He had never ceased working on investigations in photography, and it was well known what a large amount of successful work he had done. He thought Mr. Thorne Baker might rightly plead that there was perhaps a little want of appreciation of the importance of photography in so many directions. It was a little to be regretted that the number of people taking an active interest in photography—he meant those interested in carrying out all the processes of photography, and not only those who were merely using the lens and exposing it—had decreased. He supposed, however, that that was inevitable, because the younger generation at the present moment was distracted; it did not know whether to leave wireless to take up photography or not; but when those two sciences were brought more closely together, and each was helping the other, then the next generation would be working at both at the same time. It was only possible to go on making great strides in researches in a subject which was of such value in its practical applications when there was in the country a flourishing industry in connection with it; and it was to be hoped that in this country we might not cease always to have a flourishing photographic industry.

One could remember many of the matters mentioned by the author—for instance, the use of dry plates for spectrum photography in the case of very feeble lines. In the old days photo-

graphers had been in the habit of slightly fogging the plate, and in the complete explanation of that effect and what was really being done lay a very important discovery.

The vote of thanks was put and carried unanimously.

MR. THORNE BAKER, in reply, said the paper had not been an easy one to write; yet he felt that the time had to come when it ought to be put on record what a very large field photographic work was covering. Photography and photographic chemistry had risen to the dignity of one of the great sciences. He remembered 30 years ago, when he had been a boy at school, that he had taken out a patent for a photographic paper which had actually been put on the market, and incidently had lost its producers a certain amount of money. The conditions had been very different then. There were a great many people who had to do everything for themselves, and photography had then been quite a delightful science, because, although one did not have to make the plates one had to dabble in everything. To-day an individual merely bought a Kodak or a snapshot camera, pressed the button and sent the films to a chemist to be developed. That was not photography. The amateur photographer had disappeared, but he had done very remarkable things. In the many fields of science the applications of photography which had taken the old amateur's place were equally fascinating, and, of course, were of very much more real value to the progress of the world. In a research laboratory, like the one in which he had the privilege of working at the present time, scientific men all over the world came up against difficult problems or new problems which they could not understand, and they asked the photographers to help them out. In that way photographers got a versatility of knowledge which could not be obtained in other branches of physics. He could have gone on for two or three hours, but he had only given a bare outline of the hundreds of things which came the way of photographers in the course of years. Possibly the only way of dealing completely with the subject would be either to give a course of lectures or to write a book. The applications of photography to-day were so many and so great that the man in the street had no knowledge of the part photography was playing in his everyday life.

The meeting then terminated.

EXTRA MEETING.

FRIDAY, APRIL 4TH, 1924.

HIS EXCELLENCY THE BRAZILIAN AMBASSADOR in the Chair.

The CHAIRMAN, in introducing Mr. Booth, quoted the opinion of Alexander Van Hamoldt, according to which the valley of the Amazon was the world's reservoir of the future. Of that mighty river the speaker only knew the mouth, having once been in Pará and witnessed the phenomenon of the pororoca, *i.e.*, the struggle between the fresh water and the tide. Mr. Booth, who was personally interested in the development of the Amazon, was about to give information to the audience, and to himself, which would certainly be profitable to their minds. The Brazilians did not know much about Brazil, possibly because they looked at her with eyes of sentiment, whereas foreigners saw it with eyes which were not obscured by sentimental prejudices. He had noticed, however, in England that when Englishmen spoke about Brazil, they did so with a good deal of benevolence. Englishmen saw in Brazil a new country well worth cultivating in view of future trade relations. Brazil appreciated England's sympathy in her efforts to become a great nation, and reciprocated that feeling by friendship and admiration for the British Empire.

The following paper was then read:—

THE AMAZON VALLEY AND ITS DEVELOPMENT.

BY GEORGE MACAULAY BOOTH,
Director of the Bank of England and of the Booth Steamship Company, Ltd.

The Amazon Valley drains an enormous area—on the south side more than half the Northern section of Brazil; on the west side Bolivia, Peru, Ecuador and Colombia, while on the North, both Venezuela and the Guianas of England, France and Holland come within its area.

The basin draining into this great river is as large as the whole of Europe. The Amazon Valley itself follows the line of the Equator, and for a distance of many miles on each side of the river the low-lying land is densely covered with forest. Here are found an astonishing variety of natural products and there is much to interest the naturalist, the botanist and the sportsman. Furthermore, the business man has been drawn into the area by reason of the great commercial value of many of the products that grow naturally in this vast wild region.

The district, as a whole, is scarcely developed owing to the difficulty of communication. This great basin is like Venice; it has no roads and there is no communication except by water, and I have been told that the network of rivers forming the Amazon system has a total length of 150,000 miles, of which about 30,000 miles are open to steam navigation. The total length of the Amazon River from east to west, that is to say, from Para to the Andes mountains, lying to the west of Iquitos, is about 2,500 miles. The total area drained

by this great river falls little short of 3,000,000 square miles.

At the mouth of the Amazon its width almost approximates to a sea; the Northern edge being about 200 miles from the southern edge, while the delta in between is partially blocked by innumerable islands. At times, on its long journey, the Amazon becomes very narrow, but on the other hand, it frequently reaches a width of 10 miles, even as far as 1,000 miles from the coast.

A glance at the map will show that on the west coast the Andes lie about 300 miles from the Pacific. These mountains are over 16,000 feet high. In another 300 miles from their summits the land falls away just as steeply, and Iquitos, in the Upper Amazon, is only 1,200 feet above sea level, although more than 2,000 miles from the Atlantic mouth of the river.

This great mass of water flows sluggishly across the huge Continent of Brazil, the whole of which has been created during past ages from the detritus washed down by the torrential tropical rains which fall periodically among the ranges of the Andes.

The traveller by an ocean steamer meets the Amazon about 200 miles from land. While still on the blue waters of the South Atlantic, he notices the ocean taking on a yellowish tinge, which tells the story of the Amazon mud being carried out to sea by the great volume of water flowing through the 200 miles wide delta and mouth.

For many years no ocean liner dreamt of going further than Para. River boats, canoes and launches pushed their way up, but it was not until about 1880 that sufficient experience had been gained to make possible the commercial risk involved by sending an ocean vessel up to the great town of Manaos, just under 900 miles from Para. Some years later it was found possible to despatch ocean vessels to Iquitos, one of the most interesting ports in the world. It is a Peruvian Port and at the same time an Atlantic Port, for by Treaty the waters of the Amazon are International and vessels can pass freely from Para to Manaos, and Manaos to Iquitos without any special licences from the respective Governments.

The City of Para, which is the emporium of the Lower Amazon, is an early Portuguese Settlement, of which interesting traces can still be seen in the older parts of the town; but visitors will be particularly attracted by the tropical forest, with its vivid lights and shades.

The reason why so much difficulty was experienced in penetrating the interior from the coast was the impossibility of discovering, for many years, a channel through the innumerable streams of the Amazon delta. What was finally discovered as the key to this position is now known as the "Narrows." The river here is of ample depth, but is also so narrow that in many places one steamer cannot pass another, and a code of signals has to be arranged to avoid getting into difficulties. The forest on each side is particularly dense and this wall of green foliage stays with the traveller from the Delta to the Andes.

At some of the sharp turns it is possible for those on board ocean going vessels to pick the leaves off the overhanging trees of the equatorial forest, and so great is the displacement of water caused by the large vessel that the little pile-dwellings on the low banks get swamped by a regular tidal wave. The native children, of whom there appears to be a large number in almost every thatched hut, thoroughly enjoy jumping into their canoes and tossing about on the big wash. Children who live in such surroundings have not, as you would expect, much trouble with clothing, and they can all swim, so that if the canoe gets swamped no harm is done. In this region there is a motto, "Plenty to eat and nothing to wear."

The caboclo, as he is called, who lives in such a hut, can get all the fish he wants to eat and grow all the oranges and bananas he desires, existing at the cost of very little labour. He is most disinclined to work, until tempted by the desire for modern appliances, such as gramophones and sewing machines. To earn enough money to purchase these he sallies forth, with much objection, to gather rubber or nuts.

The rubber is gathered by tapping a tree called the Angora Braziliensis and preserving the milk in smoke on a paddle, which is turned constantly and wrapped in the latex until the whole has become coagulated.

At certain points along the river road to Manaos there are beautiful clearings which enterprising planters have tried to turn into English parks to vary the monotonous lines of dense tropical forest. One of the largest fresh water fish in the world has its natural habitat in the Amazon. This fish is called the Piraracu, and it forms a

staple diet among the natives. It has never been known to be caught by hook and line, but is harpooned, and the largest specimens measure 6ft. in length and 400 lbs. in weight.

Shoals of alligators are common sights at certain times and places. These repulsive beasts often bask in the sunshine and tempt the enthusiast with a rifle.

One of the most curious denizens of the forest is the ant-eater, a creature of whom all the other animals are afraid; even the fierce jaguar respects the terrible claws of this beast, who is otherwise most gentle and feeble, gaining its livelihood by tearing asunder the large ant-hills, from which it gains its food. Another queer creature of this region is the piranha, or cannibal fish, which is easily the most dangerous of all. They exist in great numbers and are ferocious meat eaters. Any man or animal that enters the river where they exist will have the flesh taken from his bones in a few moments, and if he cannot reach the shore in a minute or two, will undoubtedly be destroyed.

I will now take you on to Manaos, between which place and Para there are nothing but tiny clusters of caboclo huts. Manaos is an old settlement and in the quay wall of Manaos Harbour there is set a stone taken to Brazil by the Jesuit Fathers in the 17th century. At this town the river rises and falls some 50 feet in the course of the year, which makes a complicated problem for those responsible for handling cargo from the Liverpool liners. At high river ocean steamers can come quite close up to the banks, but at low river they have to anchor over 100 feet away and the intervening gap is bridged by a floating roadway and an aerial cargo transporter.

Theatre Square, Manaos, is paved in the most curious way. It is tesselated, and is an imitation of the old Black Horse Square at Lisbon. Sobriety is desirable when crossing its zigzag flag stones.

Near to Manaos there are fields of the famous *Victoria Regia* Lilies. These lilies have enormous leaves of sufficient strength to support the weight of a little child.

Those of my age first heard of Brazil nuts, which are, of course, the speciality of this region, from "Charley's Aunt," whose husband, John Pedro, you may remember, came from Brazil where the nuts grow. Some 30,000 tons of these valuable nuts are produced every year and are shipped to the United States of America and to Europe. They do not grow as you see them in the shops, but are encased in a large pod, the size of a good-sized grape-fruit. This is split open and the nuts, as they are known to civilisation, are found inside.

The traveller who wishes to proceed further than Manaos has to endure a somewhat monotonous and difficult journey; about 1,200 miles further on he reaches the town of Iquitos and in so doing he usually passes very interesting rafts of timber. These rafts are often of immense size and families of natives live on them, in thatch huts, for weeks at a time while they are floating down stream to the saw-mill.

Iquitos has the same physical difficulties as Manaos, the river rising and falling in the season well over 50 feet. In this town there are some 20,000 people and you will notice that for whatever else the town may be famous, it is not the pavement. Anything more appalling than the mud road in this Amazon town cannot be imagined.

Iquitos could at one time be reached by ocean vessels, but from this point onwards the traveller has to charter a launch or river steamer and here the country becomes more interesting; one is closer to mountain atmosphere; the heat becomes a little less intense and there is a sense of freshness in the air.

In my next picture you will see the village of Contamana. It looks charming in this photograph, but you can never trust the Amazon River; and a few months ago the river decided to change its course and the whole of this street with its bamboo houses and shady avenue of trees was washed away and carried down stream.

The next photograph shows you a family going down for its annual holiday to Manaos. The man has done his rubber gathering and got what little money he wants for his holiday. He ties a few logs together, builds a little hut on his raft or balsa, and off he goes, just as you or I might start for Mentone or Monte Carlo, according to our taste.

My next photograph shows the limit of navigation by river steamer. That point is just 3,000 miles from Para and you will observe what a huge river the main Amazon still is. Here it is possible to hire a small launch at a little town called Massinia, and my slide shows the launch alongside the bank. In the background are the towers of the Wireless Telegraphy Station, which the Peruvian Government has built. I am told that now they have, also, an aerodrome, for Lima, the capital of Peru, is only a few

hours' flight by air, though a long journey of a toilsome kind by any other route. You may well imagine that the river is a most suitable course for waterplanes, as they can come down on many occasions on the river if they happen to get into difficulties.

Here you see a canoe party. The river is narrow and growing very rapid and the boys have to push hard with poles.

My next slide is a typical hut where the traveller can sling his hammock and cook his meal, and if he is wise he will have brought his meal with him from Europe, as provisions on the spot quarrel terribly with an ordinary British digestion. The people are charming and hospitable and as delighted as they are astonished to see visitors.

On every point upon which I have touched, opportunities occur for science and business to take its pleasure and use its imagination. The whole place is astonishingly undeveloped and rich and its soil is refreshed every year, indeed, every month, by fresh supplies.

Those who are energetic can continue their expeditions up the Andes. My next photograph shows you literally the source of one of the innumerable courses of the Amazon. There you see a few horses in a valley about 15,500 feet above sea level and the little stream on the left hand side of the picture is starting on its long journey through the Great Amazon Forest to the Atlantic Ocean.

DISCUSSION.

At the invitation of the Chairman, various questions were put to Mr. Booth. One gentleman asked what was the best time to visit the Amazon Valley—whether it was inconvenient to go during the rainy season.

Mr. Booth replied that, broadly speaking, the best time to visit the Amazon was from March to August.

Mr. E. W. Richardson asked if any trouble was to be expected from the natives. Could English people travel freely without escort?

Mr. Booth said he was glad that the question had been asked, because he had accidentally omitted one sentence from his notes, which, owing to the last speaker's question, he was now able to bring in. It was as follows:—

"Throughout the Amazon one meets these lonely Caboclos. They are one and all charming and hospitable. From first to last in my journey up the Amazon, not only in the big cities of Para, Manaos, and Iquitos, but in the smallest communities and in the single huts of the Caboclos a most pleasing feature to the English traveller was the whole-hearted kindly hospitality displayed on every side. No effort seemed to be too great to interest and entertain the visitors, who appear without notice and without any form of introduction."

When one got into the upper reaches of the Amazon and its tributaries, however, one had to be a little more careful, because in that territory, although there were not many, there were a few natives who preferred human flesh to fish. A traveller must not proceed too far into those regions without a good guide. As a matter of fact, he himself had received nothing but friendliness, but one or two great travellers who had spent a long time there, did know quite definitely that a number of tribes still remained, especially in the remote Peruvian forests, with whom it was best to be on rather distant terms.

Dr. Rushton Parker enquired if the native rubber was equal to plantation rubber in quality. He rather supposed that it was not, and that it would not fetch the same price as plantation rubber.

Mr. Booth said it fetched very much the same price. Those who believed in Para rubber thought there was nothing like it. It had to be remembered, however, that the Mad Hatter, in "Alice in Wonderland" said there was nothing like hay for a cold; but when questioned about it he did not say there was nothing better. Personally he was one of those who thought Para rubber, which was gathered from the very biggest trees, if perfectly prepared, produced a latex which was probably a little finer than anything else; but he was prejudiced. Para rubber was certainly of very fine quality.

Mr. J. A. Murray said, after twenty years' experience of Amazon rubber, he could unhesitatingly say that, in the opiniou of the rubber trade, and everybody else, Para rubber was about one hundred times better than plantation rubber. Plantation rubber had been exported to the East from the Para, and it had got watered down and watered down. It was just like thick blood and thin blood. The Eastern rubber was the thin blood and the Para rubber was the thick blood.

A lady member of the audience enquired if there was a prepared drinking water supply in the great cities of the Amazon Valley, or was it all pure Amazon water?

Mr. Booth replied that there was prepared drinking water in all the three big towns. In Manaos it was very difficult to improve on the pure Amazon water, because Manaos was not on the main Amazon river, but it was on the Rio Negro, which looked like a Scotch burn; it was beautifully bright clear crystal water. At Para the water was full of mud and had to be filtered, but there were modern up-to-date water works which provided an excellent water.

Mr. E. W. Richardson asked whether a knowledge of the Portuguese language was necessary

in travelling through the valley; also were French and English of any use?

Mr. Booth said in Para and Manaos the cultivated city dweller talked some English and some French, but outside of those two towns and Iquitos he did not think anything but Portuguese and Spanish would be of any use. It was not a difficult thing to acquire enough knowledge of those languages for anyone who already knew French, but he would not recommend anybody to travel alone in the distant parts without a fairly good knowledge of Portuguese. Many of the natives did not speak Portuguese at all, but quite unknown tongues.

Mr. Rushton Parker said he noticed nothing had been said about coffee. Was not coffee grown to a large extent in the Amazon Valley?

Mr. Booth said that he did not think coffee was grown there. Coffee was the great product of San Paulo and Santos.

A question was then asked as to exactly where was the Italian colony of farmers to which Mr. Booth had referred. Was it easier to get at from the West coast than by the long journey up the Amazon from the East coast? To what extent was it in Peruvian territory?

Mr. Booth replied that the Italian farmers were in Peru. If it were taken that the Pacific was 300 miles from the top of the Andes and the main swamps of the Amazon were from 300 miles more down, one was still in Peru. The Italian farming group were about half way up—about 6,000 feet up in the Peruvian Montana—the Andes of Peru—on the eastern slopes. He had found quite a number of Italian farmers there. At every five or six miles he had come across an Italian farmer.

Mr. G. M. Ryan asked if the river Amazon was controlled at all in any part of its long length. If it was not controlled he could quite understand why the country was not developing. The conditions would be so unstable that people would not settle there. Floods would always be rising, and the population would never increase without permanent conditions.

Mr. Booth said that was one of the great difficulties of the territory. It was so large an area that no control had been attempted. It had merely been discovered that certain places appeared to be sufficiently high up out of the water to be stable, and those places had been selected for towns. Other places existed for towns, but they were rather far away from the rivers, and it required a good deal of enterprise to make roads and ways up to them. Some of these places were on hills, several hundreds of feet above the river, but they were surrounded by the densest forest, which undoubtedly made development very arduous work. There was no control in the sense of managing the water of the river. There was, however, control over people's rights; one had to get a licence for staking out a position. Another point was that the river arose in so many countries, that control would be very complicated. Probably that had been a great cause of retardation of development.

Dr. Rushton Parker asked whether there was much mixture between the real native and the Portuguese.

Mr. Booth replied that at the present time, in the neighbourhood of Para and Manaos, it would be very difficult, as far as the real native was concerned, to find any difference as a new race there, but the difficulty was complicated by the fact that there were large negro settlements as well. The three races were the actual Indians, the true Portuguese and the negro. Ethnologically he believed to-day it was a very complicated and curious development.

The Chairman in moving a vote of thanks to Mr. Booth for his lecture, said he had no doubt the audience were grateful for the opportunity of thinking about a territory otherwise than merely as a land of rubber and nuts. Mr. Booth had been particularly kind in avoiding making any remarks about certain unpleasant matters in connection with that territory, for instance, the rather incautious way in which its administration had lately been conducted. Mr. Booth had only mentioned agreeable things, as probably he thought there might be among those present some who had cause for complaint by reason of having invested in Para, or Amazon stock. He thought, however, that that should not prevent people from thinking kindly of the country for the future, if not for the present. Men passed, but land stood, and even if the Amazon did change its course from time to time, the land was there as a reservoir for the activities of man in the more or less remote future.

The vote of thanks was carried unanimously and the meeting terminated.

NOTES ON BOOKS.

The Works of Sir John Soane, R.A. By Arthur T. Bolton, F.S.A., F.R.I.B.A. The Sir John Soane Museum Publications, No. 8. 6*s*. 6*d*.

This work gives an account of the architectural career and work of Sir John Soane. The author, who is well-known as the Curator of the Soane Museum, has unrivalled opportunities for the study of his subject, and, as he has shown in former volumes published in this series, he is filled with genuine enthusiasm for the work of the master. Readers of the present book will probably turn with particular interest to Mr. Bolton's account of the Bank of England. This is no doubt the finest specimen of Soane's Art, and the author has very

rightly devoted to its description two chapters, illustrated by no less than forty illustrations, in addition to a frontispiece, an aerial view, which gives one a remarkably good impression of the size and proportions of this great building.

Soane began his work on the Bank in 1788, and it was not completed until 1823, when he was sixty-nine years of age. Mr. Bolton gives minute details of the building including many particulars of the cost. The estimated total for the expenditure over the forty-five years was £866,602 0*s.* 8*d.* At the time when the building started, bricklayers' wages were 3*s.* 4*d.* per day, and labourers' wages 2*s.* 2*d.* The present wages for a day of the same duration would be for bricklayers, 19*s.* 6*d.*, and for labourers, 14*s.* 9*d.* The cost of materials has risen in much the same proportion. Brickwork, which cost £9 per rod, now costs about £30, while tiles have risen from 30*s.* to 100*s.* per thousand.

Soane was an enormously hard worker—his office hours were 7 to 7 in summer and 8 to 8 in winter. He thus got through a great quantity of work, and an imposing list of his buildings appears in an appendix. Other appendices include lists of Soane's private clients, and of his pupils, assistants and clerks—in short, Mr. Bolton has been at the utmost pains to omit nothing which may throw any light on the work and methods of the master.

MANGROVE BARK IN SUMATRA.

Up to the present time, writes the United States Consul at Medan, the mangrove bark produced in the Medan district has been an article for local export only, most of it being shipped to Penang in the Straits Settlements. At this point it is gathered for trans-shipment in larger quantities to Hongkong, Amoy, and even as far North as Shanghai. Small lots of 1,000 or 2,000 bundles have also been forwarded from Penang to the United States.

Ninety-five per cent of all the mangrove bark exported from the Medan district grows along the low swampy north coast of the Province of Atjeh in the neighbourhood of Langsa, the chief port. A small quantity comes from the little port of Idi, farther west. About 60,000 bundles of bark are exported monthly from Atjeh. Each bundle is about 27 inches long and weighs 40 catties or 54 pounds. The total thus approximates 1,500 tons a month or 18,000 tons each year.

There are two species of mangrove tree—the Tengar, with reddish brown bark, which is first quality, and the Bacau, or second quality, the bark of which has a whitish surface. Of the total quantity of bark produced 60 per cent is of the Tengar variety and 40 per cent of the Bacau. The mangrove tree grows to a height of 70 to 80 feet above the water level. The trees are cut down and the bark is stripped off in lengths of 27 inches. The bark is then dried in the sun and bundled together with strips of rattan. When shipped as deck cargo, as frequently happens in these eastern waters, the bundles of bark are placed in sacks as a protection from the weather.

The collecting and local marketing of the mangrove are done wholly by Chinese. No attempt is made to boil the bark to obtain the extract used in tanning. It is understood that this is done in some parts of Borneo where mangrove bark is gathered. Two European companies hold mangrove swamp concessions and grant rights to the Chinese to gather the bark upon the payment of a royalty. The Dutch Government also grants rights to Chinese to gather bark on Government swamp land and collects a small tax for each bundle gathered.

TURKISH GUM TRAGACANTH PRODUCTION.

Gum tragacanth is the product of several species of shrubs, genus Astragalus. The shrubs grow to a height of three or four feet, and are found in a wild state on the highlands and mountains of Turkey, Persia, and Syria. No special cultivation has ever been attempted. The greater part of the Anatolian crop is gathered by peasants each year during the months of June and July.

According to a report from the United States Trade Commissioner's Office at Constantinople, the most important regions producing gum tragacanth are Caesarea, Angora, Yosgad, Karaman, Michalitch, Konia, Karahissar, Everek, Nigde, and Nidel. The first five centres named probably produce the best qualities. When collected and dried, the gum is packed in sacks, taken to the nearest village, and sold to jobbers, who are usually the agents of the exporters in the large ports. Thereupon it is transported to Constantinople or Smyrna, where it is graded for exportation. The entire product is exported.

Tragacanth is graded according to quality, irrespective of the point of origin, and usually according to the following classification.

Firsts (fiores or extras)—the finest white, translucent flakes.

Seconds—yellowish flakes of good quality.

Thirds (Biondos)—clear, yellow flakes.

Fourths—dark yellow and opaque gum.

Fifths (Scarto and terreuses)—flakes of all cuts which are damaged by rain and dirt, mixed and sold at a low price.

The gum comes from the producer in sacks containing about 60 okes each (oke = 2.8 pounds). The finest qualities are repacked for export in wooden cases containing about 120 kilos (kilo = 2.2 pounds), while the inferior grades are shipped in jute sacks, 75 to 100 kilos to the sack.

In the years immediately preceding the World War, production is estimated to have been about 5,000 to 6.000 sacks annually. During the war it was greatly neglected and barely reached 1,500 sacks. Most of the peasants were in the army and transportation was inadequate. Very small amounts were shipped to the central European countries until the last two years of the war,

when the annual exports were from 800 to 1,000 sacks. Production rose steadily after the armistice and is now approximately 5,000 sacks per annum.

A certain amount of Persian gum tragacanth comes to the Constantinople and Smyrna markets and is re-exported. This gum is of a very fine quality, being white and translucent, and is produced in flakes and ribbons. In many respects it resembles the Anatolian firsts, but has a higher yield than the latter. Persian gum is used chiefly in medicine and in the better grades of confectionery. Syrian gum, small quantities of which used to be handled in Constantinople, comes in thin, vermiform pieces. It is very translucent, yields more than Anatolian gum, and is used for purposes similar to those of the Persian gum. Bitlis gum or "hog tragacanth" is the product of a species which grows in the region of Bitlis, and throughout Kurdistan, and is used largely for dressing and stiffening rough cloth materials, such as jute sacking.

MANUFACTURING INDUSTRIES OF MEXICO.

In spite of the prominence of minerals, oil and agricultural products in the export statistics of Mexico, that country is also a manufacturing country of some importance; its total production of manufactured articles is claimed to exceed that of any other Latin-American Republic. This is due partly to natural advantages and partly to the policy of encouraging the establishment of new industries by the imposition of high, and in some cases prohibitive, duties on foreign goods.

Of the industries which flourish under this protective wall, writes H. M. Consul-General at Mexico City, probably the most important, from the points of view both of capital invested and of value of output, is that devoted to the manufacture of cotton textile goods. The largest factory is situated in Orizaba and is equipped with machinery of a modern type which is capable of performing all the operations from the cleaning of the raw cotton to the dyeing of the finished cloth. More than 100 other factories are situated throughout the Republic and, although the industry is suffering at present from depression, owing to the high price of the raw material, combined with over-production and lack of demand, there is no doubt that it is an economic factor of great importance in the manufacturing development of the country.

The manufacture of tobacco, especially in the form of cigarettes, for which the demand seems to be inexhaustible, is also an important and flourishing industry. Two large factories of the most up to-date style are established in Mexico City and there are scores of smaller factories for producing cigars and cigarettes scattered throughout the Republic.

Boots and shoes are also manufactured on an increasing scale. In Mexico City there are two large factories owned largely by British capital, besides others of considerable importance. The quality of the goods produced is high and, although it cannot equal the best class of British-made shoes, it is equal to the requirements of the public. For this reason the importation of footwear seems bound to decline in the future.

The brewing of beer, the distillation of spirits, and the manufacture of wines and beverages are all flourishing industries.

Paper is made in the Republic, there being two large mills devoted principally to the production of newsprint, in which they are capable of satisfying the requirements of the country. They also make a certain amount of bond, writing and other papers, but have not yet reached the stage where they can compete with the imported article along these particular lines.

Cement of good quality is manufactured locally, one important factory being controlled by British interests. Structural steel and ironwork, and other iron and steel products are well represented. The manufacture of jute bags at Orizaba is carried on by a very important British firm.

Other articles of local manufacture of importance are:—woollens, furniture, hats, chinaware, glass bottles, soap, jams and preserves, matches, clothing and rubber goods including motor tyres, explosives, musical instruments, vehicles, &c.,

A NEW HARBOUR FOR INDIA.

According to the *Indian Textile Journal*, there is now every prospect of the long-contemplated project of a harbour at Cochin becoming an accomplished fact in the near future. All who are familiar with India and Indian shipping have long felt the desirability of having another harbour on the West Coast of India, south of Bombay, where vessels could discharge cargoes all the year round, and the agreement which has just been signed between the Madras Government and the two adjacent Native States interested in the project marks a great step forward towards the realisation of this need. In 1918 a scheme was submitted to the three States concerned—Madras, Cochin and Travancore—for the development of the port of Cochin at an estimated cost of Rs. 203½ lakhs. It was subsequently decided to carry out this scheme in four different stages—the first of which was to be the opening of a bar at a cost of Rs. 9 lakhs. It was, however, found necessary to first of all carry out extensive dredging operations and these were not completed until May of last year, when a channel 150 feet wide and 17 feet deep was completed through the bar and also channels inside the bar to prevent over-flowing during the monsoons. Careful observation was kept during the last monsoon and the conclusions resulting from these appear to be favourable, so that it is hoped that the other parts of the original scheme may ultimately be carried out. Until the trade of the port reaches an average of Rs. 15 crores a year it will be regarded as a "minor" port; and the three adjacent States will be responsible for the financial working of the scheme. When the aggregate trade averages over Rs. 15

crores, the port will become a "major" port and automatically pass under the control of the Indian Government, who will re-imburse the expenses incurred in the carrying out of the first stage of the scheme. A Port Trust is to be formed upon similar lines to those now in existence at Calcutta, Bombay and other Indian ports. It is claimed that this new harbour, when completed as planned, will make it possible for vessels to enter and discharge and load cargoes all the year round.

TUNISIAN TUNNY FISH INDUSTRY.

According to the recent annual report on the trade of the Regency of Tunis, by the Acting British Consul General at Tunis, the tunny fish industry, a source of considerable wealth in Tunisia, is both curious and of considerable commercial interest. The fish is noticeably larger than the tunny which is caught on the coasts of France and Spain, and the methods used for catching it are very different. Whereas the "Gascony" tunny does not generally exceed 60 pounds in weight, and is usually caught with a line, the Mediterranean tunny runs to some 400 pounds in weight, and is only taken in nets. Its flesh is of darker colour and coarser texture, and is used almost entirely for canning in oil. 95 per cent. of the fish caught in Tunisia is exported, mainly to Italy, the rest being consumed locally.

The most important tunny fishing station is that of Sidi Daoud on the Gulf of Tunis, nearly opposite Carthage. A highly-organised fishing camp has been constructed there together with a canning factory. The tins are actually made on the spot, as well as the wooden cases ready for export, although the locality is served by no railway line, nor even a good road. Both the tinplate used and the timber, together with all other material, such as olive oil and salt, have to be brought to Sidi Daoud either on rough country carts or, more often, by small sailing vessels and light steam craft plying across the Gulf.

This fishing station is only in activity during the months of April, May, June and July, and of this period little over one month, namely, June, is actually taken up with the fishing, the rest of the time being used for preparation and organisation.

A good average day's haul is 1,000 fish averaging some 200 lbs. each, namely, a total of 100 tons. A good average total for the season is 1,000 tons or more.

THE GINGER INDUSTRY OF CANTON.

Dried and preserved ginger, as well as the raw product, are exported from the Canton district, although Hongkong is the centre for the exportation of ginger. Ginger root from Canton and other points is imported into Hongkong, where it is preserved and dried for shipment to consuming countries.

The year 1922 was a favourable one for the ginger industry. The exportation of fresh ginger from Canton increased from 7,046,074 pounds, valued at about £25,000 in 1921, to 9,779,357 pounds, valued at about £38,500 in 1922. Only a small amount of preserved ginger was exported from Canton, as most of the ginger is preserved at Hongkong.

According to the United States Vice-Consul at Canton, the ginger factories there buy ginger from a few Chinese dealers, who collect from many small up-country growers. The ginger is shipped to Canton by junk. Stem ginger, or the young tender shoots of the plant, is cut up into small sizes suitable for sale. Cargo ginger is treated as it comes from the growers and is brought into Canton in pieces weighing from four ounces to a pound.

After arrival at the factory the ginger is given a preliminary washing in the river. Then it is put into a vat with a capacity of about 360 catties (equivalent to 480 pounds) and boiled for about an hour. After draining off the water, ginger and sugar are mixed in equal proportions, with enough water for boiling. This mixture is boiled in the vat for an hour, and the resulting preserved ginger is packed in casks of 168 catties (224 pounds) for shipment abroad. It is also shipped in cases containing jars packed in straw. The cases are made of local timber.

The same process, up to the boiling with sugar, is followed in the manufacture of dry ginger. In this case very little water is added after the ginger is mixed with sugar. The ginger is boiled until dry, after which it is removed from the vat and packed in one-pound tin boxes.

MEETINGS OF THE SOCIETY.

INDIAN SECTION.

MONDAY JUNE 30, at 4.30 o'clock.—J. C. FRENCH, I.C.S. "The Art of the Pāl Empire in Bengal." THE RIGHT HON. THE EARL OF RONALDSHAY, G.C.S.I., G.C.I.E., will preside.

DOMINIONS AND COLONIES SECTION.

MONDAY, JUNE 16, at 4.30 o'clock.—C. V. CORLESS, M.Sc., LL.D., "The Mineral Wealth of the pre-Cambrian in Canada." SIR RICHARD REDMAYNE, K.C.B., M.Sc., M.Inst.C.E., M.I.M.E., M.I.M.M., F.G.S., Chairman-Governor, Imperial Resources Bureau, will preside.

Journal of the Royal Society of Arts.

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18 JUL 1924

FRIDAY, JUNE 20, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

FINANCIAL STATEMENT FOR 1923.

The following statement is published in this week's *Journal* in accordance with Sec. 40 of the Society's By-laws:—

INCOME AND EXPENDITURE ACCOUNT.

January 1st to December 31st, 1923.

Dr.

		£ s. d.	£ s. d.
To *Journal*, including Printing, Publishing and Advertisements		3,132 19 7	
Library and Bookbinding		116 2 11	
Medals :—			
Albert	43 15 0		
Society's	27 0 0		
		70 15 0	
Sections :—			
Dominions and Colonies	81 16 10		
Indian	123 16 8		
		205 13 6	
Cantor Lectures		125 12 6	3,651 3 6
Expenses of Examinations			8,838 14 6
House :—			
Rent, Rates, and Taxes		442 3 8	
Insurance, Gas, Coal, Expenses and Charges incidental to Meetings		571 16 9	
Repairs		417 17 8	1,431 18 1
Office Expenses :—			
Salaries, Wages, and Pensions		3,669 3 6	
Stationery and Office Printing		412 19 11	
Advertising		45 10 0	
Postages, Parcels, and Messengers' Fares		282 11 7	4,360 5 0
Committees :—			
General Expenses			59 10 2
Industrial Art Committees			82 4 6
Balance, being Excess of Income over Expenditure transferred to Capital Account (see Balance Sheet)			1,383 13 8
			£19,807 9 5

Cr.

	£ s. d.	£ s. d.
By Subscriptions	6,461 6 0	
„ Life Compositions	330 10 0	
		6,791 16 0
„ Interest and Dividends on Society's Investments	338 13 3	
„ Ground Rents	369 9 0	
„ Interest, Dividends, and Ground Rents from Trust Funds for General Purposes	499 16 9	
Do. from Building and Endowment Funds	22 7 5	
		1,230 6 5
„ Sales, etc. :—		
Journal	266 13 7	
Do. Advertisements	281 8 3	
Cantor Lectures	11 0 2	
		559 2 0
„ Examination Fees and Advertisements in and Sale of Examination Papers		10,896 6 8
„ Charges for Expenses for the use of Meeting Room		262 10 0
„ Rent of Cellars		67 8 4
		£19,807 9 5

TRUST INCOME AND EXPENDITURE ACCOUNTS.

Dr.

	£	s.	d.
Balance forward	691	16	2
	£691	16	2

Cr.

	£	s.	d.	Trust Accumulations, Dec. 31st, 1923. £	s.	d.
John Stock Trust—						
By Balance, January 1st, 1923	32	6	5			
„ Interest on Investments	3	10	2			
				35	16	7
North London Exhibition Trust.—						
„ Balance, January 1st, 1923	54	14	3			
„ Interest on Investments	6	14	10			
	61	9	1			
Less Prizes awarded	15	19	3			
				45	9	10
Dr. Aldred's Trust—						
„ Balance, January 1st, 1923	44	9	7			
„ Interest on Investments	7	14	5			
				52	4	0
Thomas Howard's Trust—						
„ Balance, January 1st, 1923	83	11	10			
„ Interest on Investments	19	19	8			
	103	11	6			
Less Cost of Lectures & Printing	45	12	6			
				57	19	0
Mulready Trust—						
„ Balance, January 1st, 1923	48	7	5			
„ Interest on Investments	5	5	4			
	53	12	9			
Less Prizes awarded	20	0	0			
				33	12	9
Dr. Swiney's Trust—						
„ Balance, January 1st, 1923	160	0	0			
„ Ground Rents (Income from)..	180	0	0			
	340	0	0			
Less Transfer to the Society's Income and Expenditure Account	140	0	0			
				200	0	0
Francis Cobb Trust—						
„ Balance, January 1st, 1923	47	13	5			
„ Interest on Investments	8	18	10			
				56	12	3
Le Neve Foster Prize Trust—						
„ Balance, January 1st, 1923	19	19	4			
„ Interest on Investments	5	16	0			
				25	15	4
Fothergill Trust—						
„ Balance, January 1st, 1923	62	11	10			
„ Interest on Investments	13	12	5			
				76	4	3
Trueman Wood Lecture Trust—						
„ Interest on Investments	32	14	8			
Less cost of Sir William Bragg's Lecture (including printing)	32	14	8			
				—	—	—
Benjamin Shaw Trust—						
„ Balance, January 1st, 1923	4	3	2			
„ Interest on Investments	4	13	6			
				8	16	8
Cantor Trust—						
„ Interest on Investments	140	14	1			
„ Ground Rents (Income from)..	141	0	0			
	281	14	1			
Less Transfer to Society's Income and Expenditure Account	281	14	1			
				—	—	—
Davis Trust—						
„ Interest on Investments	78	2	8			
Less Transfer to Society's Income & Expenditure Account	78	2	8			
				—	—	—
„ Sir George Birdwood Memorial Trust—						
Interest on Investments	36	15	0			
Less cost of Sir J. H. Marshall's Lecture (including Printing)	36	15	0			
				—	—	—
Russian Embassy Prize Trust—						
„ Balance, January 1st, 1923	10	0	0			
„ Interest on Investments	5	0	0			
	15	0	0			
Less Prize awarded	5	0	0			
				10	0	0
Dr. Mann Trust—						
„ Balance, January 1st, 1923	72	17	0			
„ Interest on Investments	51	8	6			
	124	5	6			
Less Cost of Juvenile Lectures	35	0	0			
				89	5	6
Owen Jones Memorial Trust—						
To Interest on Investments	15	13	4			
Less. Balance over-spent 1922 .... 10 7						
Do. Prizes awarded 15 2 9						
	15	13	4	—	—	—
				£691	16	2

1924—Jan. 1. By Balance brought forward £691 16 2

BALANCE SHEET, December 31st, 1923.

Dr.

	£	s.	d.	£	s.	d.
To Capital Account—						
As on January 1st, 1923 ..	71,863	12	5			
Donations re Building Fund	275	6	6			
Income and Expenditure Account Balance	1,383	13	8			
				73,522	12	7
,, Sundry Creditors				1,291	15	9
,, Bank Overdraft (Building Fund Account)........				7,634	13	9
,, Industrial Art Fund (Donations received and not yet expended)				703	14	6
				83,152	16	7
,, Trust Funds—						
Capital Account	16,899	7	5			
Accumulations under Trust Income and Expenditure Account	691	16	2			
				17,591	3	7
,, Sundry Creditors				15	12	6
				£100,759	12	8

Cr.

	£	s.	d.	£	s.	d.
By Freehold Premises						
18 and 19, John Street as on December, 31st, 1922	48,151	6	2			
Alterations, &c., (less Sales)	2,241	10	5			
				50,392	16	7
,, Books, Pictures, etc.......				10,000	0	0
,, Investments (see schedule)				17,481	8	5
,, Subscriptions outstanding				2,705	0	0
,, Sundry Debtors and Ground Rents outstanding				828	19	7
,, Paid on Account of 1924 Examinations				1,650	0	0
,, Cash at Bank on Current Account (*less* cash in Transit)				712	0	8
				83,770	5	3
,, Trust Funds—						
Investments	16,899	7	5			
Ground Rents, etc.	90	0	0			
				16,989	7	5
				£100,759	12	8

We have audited the above Accounts and Balance Sheet for 1923 *with the books, accounts and vouchers relating thereto, and certify them as being in accordance therewith. We have verified the Bank Balances and investments.*

KNOX, CROPPER & Co.,
Chartered Accountants.

Spencer House, South Place, E.C. 2.
14 June, 1924.

SCHEDULE OF THE SOCIETY'S INVESTMENTS.

(*as valued December,* 1922).

				£	s.	d.
Ground-rents (amount invested)				£10,496	2	0
£217	0	0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	157	0	0
£500	0	0	New South Wales 4 per Cent. Stock	445	0	0
£509	0	0	Canada 3½ per Cent. Stock	430	0	0
£100	0	0	Queensland 4 per Cent. Stock	97	0	0
£530	10	1	New South Wales 3½ per Cent. Stock	514	11	0
£500	0	0	Natal 4 per Cent. Stock	445	0	0
£321	15	9	Metropolitan Water Board "B" Stock	209	3	0
£6	0	0	New River Company Shares	6	0	0
£3,408	14	6	India 3½ per Cent. Stock	2,181	11	8
£500	0	0	South Australia 4 per Cent. Stock	500	0	0
£2,000	0	0	War Loan 5 per Cent..	2,000	0	0
				17,481	8	5

TRUST FUNDS INVESTMENTS SCHEDULE.

	£	s.	d.
Alfred Davies Bequest	£1,953	0	0
Mr. Swiney's Bequest	4,477	10	0
Mr. Cantor's Bequest	2,695	11	3
Mulready Trust	105	9	9
Howard Trust	571	0	0
Owen Jones Trust	522	3	2
Mr. Cantor's Bequest	3,273	16	6
	648	19	7
J. Murray and others, Building Fund	20	16	4
	38	11	0
Francis Cobb Trust	255	14	1
Le Neve Foster Trust	105	11	7
	42	2	1
John Stock Trust	70	4	0
Shaw Trust	93	12	0
North London Exhibition Trust	134	17	0
Fothergill Trust	272	7	6
Aldred Trust	154	8	0
Endowment Fund	394	7	0
"Trueman Wood" Lecture Endowment Fund	654	15	7
Sir George Birdwood Memorial Fund	734	19	9
Russian Embassy Prize	100	0	0
Mann Trust	1,028	9	2

	£	s.	d.
Great Indian Peninsula Railway 4 per cent. Guaranteed Debenture Stock	1,800	0	0
Ground-rents (amount expended)	£4,477	10	0
Do. do. do.	2,695	11	3
National 5 per cent. War Bond, 1927	109	10	1
Metropolitan Railway 3½ per Cent. Stock	510	9	5
India 3 per cent. Stock	423	0	0
Do. do. / Bombay and Baroda Railway Guaranteed 3 per Cent. Stock	2,573	10	0
India 3½ per Cent. Stock	20	10	0
5 per Cent. War Loan	54	18	0
New South Wales 3½ per Cent. Stock 1930-50	250	0	0
3½ per Cent. War Loan	100	0	0
5 do. do.	40	0	0
5 do. do.	100	0	0
5 do. do.	129	6	8
5 do. do.	184	15	0
5 do. do.	374	0	0
5 do. do.	210	17	6
5 do. do.	525	2	3
National 5 per Cent. War Bonds 1928	654	18	0
5 per Cent. War Loan	674	0	0
5 do. do.	91	9	3
5 do. do.	900	0	0
	£16,899	7	5

NOTICES.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One-hundred-and-Seventieth Annual General Meeting, for the purpose of receiving the Council's Report and the Financial Statement for 1923, and also for the election of Officers and new Fellows, will be held, in accordance with the By-laws, on Wednesday, June 25th, at 4 p.m.

(By Order of the Council)

GEORGE KENNETH MENZIES,
Secretary.

DOMINIONS AND COLONIES SECTION.

MONDAY, JUNE 16th, 1924; SIR RICHARD REDMAYNE, K.C.B., M.Sc., M.INST.C.E., M.I.M.E., M.I.M.M., F.G.S., Chairman Governor, Imperial Resources Bureau, in the Chair.

A paper on "The Mineral Wealth of the Pre-Cambrian in Canada" was read by Mr. C. V. Corless, M.Sc., LL.D.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

TWENTIETH ORDINARY MEETING.

WEDNESDAY, MAY 7TH, 1924.

ADMIRAL OF THE FLEET, SIR HERNY B. JACKSON, G.C.B., K.C.V.O., F.R.S., M.I.E.E., in the Chair.

The paper read was:—

WIRELESS NAVIGATION.

By J. ROBINSON, M.Sc., Ph.D., F.Inst.P.,
Head of Wireless and Photography Department, Royal Aircraft Establishment, Farnborough.

Some features of wireless navigation are already well known. The basis of the subject is that it is possible to determine the direction towards a wireless transmitting station, and the instruments for doing this are usually called direction finders. Most people are aware of the uses made of these instruments by our Fighting Forces during the war. In Zeppelin attacks, our organisation of direction finding stations, with their means of communicating with London, gave our headquarters staff immediate information as to the position of the Zeppelins, so that we were warned of the

approach of the airships, and each district was darkened as required. The Zeppelins themselves transmitted, so that the German direction finding stations could work out the position of the airships, and it is of interest that in these cases wireless navigation proved both of use and disadvantage to our late enemy.

Again, our direction finding stations were of use in finding the whereabouts of German submarines. The submarines were fitted with wireless transmitting and receiving apparatus for purposes of communication with their bases. When they used their transmitters, bearings were found on them by our various direction finders, and their positions were discovered. The fact that our stations were kept most busy at nights was testimony to the efficiency of our various defence methods. An interesting episode happened in the Mediterranean, which was only discovered by us after the war. The enemy knew of our methods of sending out wireless broadcast signals giving the position of any enemy submarine, and on occasions, where a submarine was not sure of its own position, it came to the surface and made a transmission, knowing that our direction finding organisation would give its position. On receiving the information required the submarine naturally departed as far as possible from the position indicated to our submarine hunters.

Some time ago the fact was disclosed that our direction finders had some important influence during the Jutland Battle. Early information was received of the movements of the German Fleet, and Admiral of the Fleet Sir Henry Jackson, who was then First Sea Lord, was able to issue early instructions to our own Naval Forces.

These facts show that Great Britain was in the forefront of the development of wireless navigation, and we can claim to have carried the development to a higher pitch than any other nation during the war. Post-war application perhaps does not leave us with the same superiority.

Long before the advent of wireless, navigation had become very highly developed. Many methods were available to give the mariner information of his position and of the course he should steer. These methods, however, were not infallible, as ships were lost owing to faulty navigation. Wireless gives a further method for determining position, and as a navigational method it is already diminishing the number of ships lost, and by more universal application it will undoubtedly add materially to the safety of life at sea. In the cases where the better known navigational methods fail, *i.e.*, in fogs, or during persistent cloudy weather on long voyages, wireless is exceptionally useful. Unlike light, wireless waves are unaffected by fog. Thus by the aid of wireless, ships can proceed during fogs with an accurate knowledge of their positions, and so considerable time can be saved.

Another aspect of navigation must nowadays be considered, *i.e.*, for aircraft. In this case wireless must play an even greater part than it does for ships, and so much so that it will become absolutely essential for aircraft. One reason for this is that drift plays a much more important part in the air than it does at sea, so that dead reckoning methods are not so easy to apply. A cross wind of thirty miles per hour has a serious influence on an aeroplane doing 100 miles per hour, and the wind may change in force and direction without the pilot being aware of it. In cases of over sea flights and of flights above clouds, it is thus of great importance to make use of all possible navigational methods, and wireless will play a very important part.

From the navigational point of view there is nothing new for mariners to learn about wireless navigation. The method is analogous to that of taking bearings on lighthouses and on known points on the coasts. Wireless introduces other fixed points, *i.e.*, wireless shore stations, with the added advantage that these stations can be at ranges much greater than the eye can see. Ranges of hundreds (even thousands) of miles can be used, though the greatest utility for ships will probably be under one hundred miles. On a point of application there is one difference from visual bearings, which is that for long distance wireless bearings it is necessary to take into account the curvature of the earth. Wireless bearings are great circle bearings, and must be treated accordingly when transferring to mercators or other form of chart.

When two or more bearings are obtained from different wireless stations, one's position can be plotted on a chart, see Fig. I. Wireless bearings are usually obtained with an accuracy of 2°. This may seem crude to some navigators, especially when compared with the precision of their astronomical

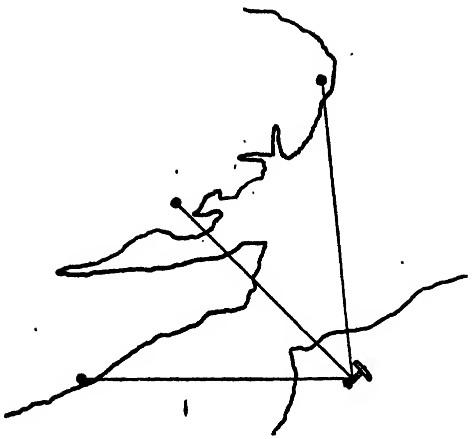

FIG. 1.

Method of locating position by means of three Fixed Stations.

observations. It is not so crude as it appears at first sight, as a number of wireless bearings from different stations can be obtained, and on plotting the various bearings they will cut each other to form various triangles, and one's most probable position can be obtained with reasonable accuracy. Again, positions can be obtained from time to time and checks obtained by the aid of dead reckoning. Again, in regions where wireless navigation is most useful it will usually be possible to have a number of wireless stations at comparatively short ranges, say, not exceeding 50 miles, in which case an accuracy of 2° is quite good.

The principle on which most direction finding systems depend is that of a single loop consisting of one or more turns of wire. If such a loop is joined in series with a tuning condenser, and suitable receiving means employed, it has the following properties. Suppose that the loop is arranged to rotate about a vertical axis, and that we tune in to waves coming from any particular station, when the loop is rotated it will be found that the signal strength alters, and that in one complete turn there are two positions where the signals are loudest, and two positions where the signals vanish. The two positions of maxima are directly opposite to each other, in other words, 180° apart, and the two positions of minima are also directly opposite to each other, the minima being at right angles to the maxima. When a maximum is obtained, the plane of the loop is pointing directly at the transmitting station, and thus when the minimum is obtained the plane of the loop is at right angles to the direction towards the transmitting station.

The reason for this change of signal strength as the loop rotates is as follows:—Wireless waves travel over the surface of the earth. Another name for wireless waves is electro-magnetic waves, a term which implies that there is an electric component and a magnetic component of the wave. There are thus three features of the waves, the direction of transmission, the electric, and the magnetic fields, and these three are at right angles to each other, see Fig. 2. The electric force is normally vertical and the magnetic force horizontal. The fact that we are dealing with waves means that both these fields are alternating rapidly. From the laws of ordinary electro-magnetic induction, it is known that if the magnetic field cutting through the plane of a loop changes, an electro-motive force is produced in the loop. For every position of this direction finding loop, except where the plane of the loop is parallel to the direction of the magnetic field, the magnetic lines of force cut through the loop and thus produce an electro-motive force. Where the magnetic lines are in the plane of the loop, no electro-motive force is produced at all. This position, by reference to Fig. 2,

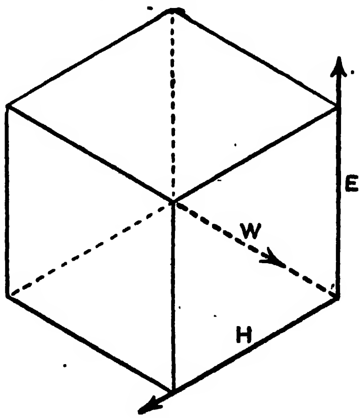

FIG. 2.

Relationship between Electric and Magnetic Fields and Direction of Propagation of Waves.

is obviously for the plane of the loop at right angles to the direction of the waves, the maximum cutting of the lines of force through the loop is obviously where the plane of the loop is in the direction of the waves, and between these two positions there are produced varying degrees of electro-motive force. We thus see why maxima and minima are obtained, and by using

suitable receivers a curve similar to that shown in Fig. 3 is obtained, which shows the relationship between the position of the loop with regard to the transmitting station and the amount of energy picked up by the loop. In this diagram the energy absorbed from any given direction is proportional to the length of a line drawn in the required direction, from the centre of the degree circle to the point at which it cuts the figure-of-eight curve.

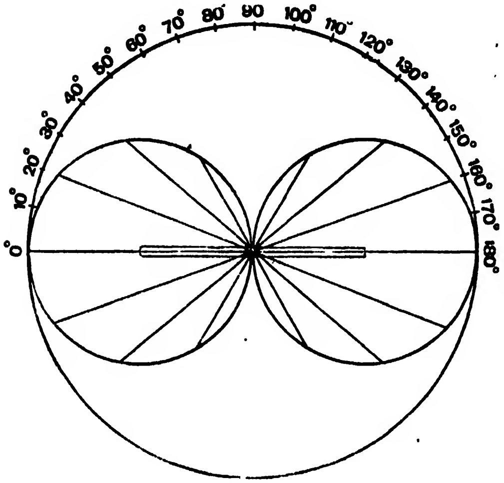

FIG. 3.
Polar Curve for Single Coil Aerial.

Unfortunately the amount of energy picked up from waves by a loop is very small. Compared with open wireless aerials the energy is very small indeed. This relation depends on the wavelengths used and on the number of turns and area of the loop. Consider an open aerial 90 ft. high and a square loop of 10 turns of 3 ft. side. On a wavelength of 1,000 metres the open aerial receives 300 times the electro-motive force received by the loop. When the wavelength is 2,000 metres this ratio is 600, and when 500 metres, the ratio is 150; the shorter the wavelength the better is the loop in relation to the open aerial. It would thus appear advisable to increase the size of the loop as much as possible. There are limits to this, however, from the point of view of convenience, and, further, from the point of view of wavelength. Although the directional properties of loops have been known for some considerable time, the small amount of energy they receive prevented use being made of them for directional purposes, to any extent, until the advent of the thermionic valve, which enabled very sensitive receivers and amplifiers to be designed.

By reference to the curve in Fig. 3, it will be seen that the most sensitive position for determining direction with a single loop is at the minimum, and that the determination of the maximum with any accuracy is impossible; this is because the variation of signal strength at the maximum is very slow. The position of the minimum can be determined with considerable precision by rotating the loop through the minimum position until signals are heard on both sides of the minimum. On a circular scale the readings on both sides of the minimum are noted and the mean angle worked out. A typical example of a single loop direction finder is shown in the slide. This form of loop, which is usually known as the single loop method, is used in the United States and in France, and to a certain extent in Great Britain.

BELLINI-TOSI SYSTEM.

Owing to the small amount of energy picked up by loops, in the early days it was necessary to use large loops, which could not be conveniently rotated. A form of apparatus of this nature was invented prior to the war, and is known as the Bellini-Tosi apparatus. This apparatus makes use of fixed loops which may be of the dimensions of 100 ft. square or even greater. Two loops at right angles to each other are used and tuned up separately. By means of an instrument known as a radiogoniometer, shown on the screen, a small rotatable coil inside this instrument is coupled loosely to two coils at right angles, these coils being respectively in the circuits of the separate aerials. It is found that by suitable connections, as this moving coil is rotated, maxima and minima are obtained as in the case of a single loop, and that these maxima and minima correspond exactly with the direction of the incoming waves. The explanation of this has been given on many occasions and need not be entered into here. Recent developments of this apparatus have led to the abolition of the tuning condensers in the main aerials. Fig. 4 shows a complete connection for this form of apparatus joined up to a single valve acting as detector. This form of apparatus had considerable use during the war, and its development to a stage of practical utility was due to British engineers, particularly Round and Prince.

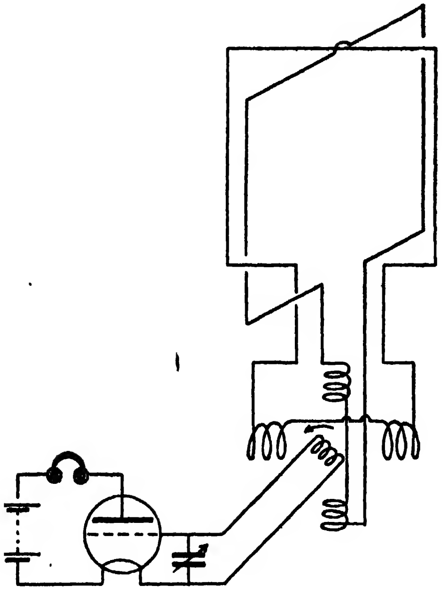

FIG. 4.
Bellini Tosi D.F. System.

ROBINSON SYSTEM.

Another system for determining the direction of the waves also makes use of two coils at right angles to each other, but in this case the two coils are capable of rotation together. These coils are used in series, and a typical set of connections is shown in Fig. 5. The object of this system is to allow bearings to be taken whilst an audible signal is heard, and it is in this respect distinct from the two preceding systems. Such a system is obviously of

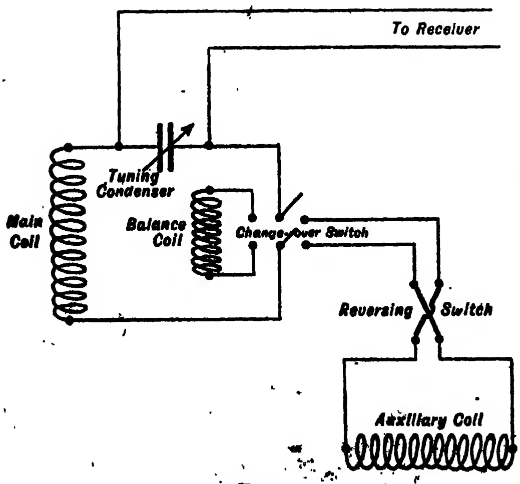

FIG. 5.
Robinson D.F. System.

great utility in many circumstances. First, it enables the signal to be read at the same time that a bearing is being taken. Secondly, in cases where external noise is very bad, as in the case of aircraft, this external noise would tend with minimum systems to make the angle of a minimum signal very wide and thus the determination of bearings inaccurate. This system is sometimes called the maximum system, because it enables the maximum position of one coil to be determined. The coils being at right angles, when one coil is on the maximum the other coil is on the minimum or zero. Suppose that one coil, called the main coil, is used alone, a rough determination of the maximum can be obtained. Now, by the use of a switch one can introduce the second or auxiliary coil to add its effect to that of the main coil. If the main coil is accurately on its maximum, the auxiliary coil will be accurately on its zero, and thus the introduction of this latter coil should make no difference, variation in tune being specially compensated for. If it does make any difference to the strength of signal then it is necessary to rotate the system slightly in order to obtain the condition where the introduction of the auxiliary coil makes no difference to the strength of signals. In actual practice the method in use is to reverse the connections of the auxiliary coil, which in effect means that the effects of this coil are added to or subtracted from those of the main coil. This system is capable of very great accuracy by making the size of the auxiliary coil many times greater than that of the main coil; the adjustment of the coil can be set to within one-tenth of a degree. In actual practice this accuracy is too great, and the ratio of the coils is chosen about two or three to one.

APPLICATION.

Having described the various reception methods for determining the direction of wireless waves, the question arises as to how these instruments can be used for actual wireless navigation, in other words, whether the instruments should be placed on shore or on the ship or aircraft. We shall first discuss the system where the direction finding stations are on the shore. In this case a system of direction finding stations is worked out so that reasonable accuracy is obtained from whatever direction the ship may be approaching, i.e., it is arranged

that the cuts should always be at as large an angle as possible. Obviously, if two bearings cut at a very fine angle the deduction of position is liable to serious error, because, the bearings being nearly parallel, the smallest error in one will make a big difference in the point at which they cut. The system of direction finding stations is then linked up with one central station by land line or by transmitting wireless stations. It is preferable to use land line wherever possible. The procedure for determining position is for a ship to make a call asking for its position. Each direction finding station works out the bearing and communicates its result to the central station, where the position of the ship is plotted from these various bearings. As soon as this is determined the central station communicates the position by wireless to the ship. A certain length of time is required for this process, of the order of five minutes, and only one ship can be dealt with at a time. Any accuracy that is required can be obtained by increasing the number of direction finding stations on the shore. This system has had considerable application. It is the system that was used by the Zeppelins during the war in their attacks on England. Again, it is the system that was used by our forces to determine the position of the enemy submarines. Obviously for war purposes it has the great disadvantage that the position is disclosed to the enemy as well as to one's friends, as in the case of the Zeppelins. The system is used to some extent in England at the present time, stations being at Flamborough Head, the Lizard and Berwick-on-Tweed. The greatest application at the present time of this system is being made in the approaches to New York Harbour. The slide shows the thoroughness with which the United States Authorities are making use of this system. A large number of direction finding stations are used, and it is stated that twenty thousand bearings are given every year. Again, this system is being used on the Civil Air Route between London and Paris. On the British side direction finding stations are installed at Croydon and Pulham. An aeroplane asks for its position by wireless telephony. Both Pulham and Croydon work out bearings, the Pulham bearing being communicated by land line to Croydon, where the position of the aircraft is worked out and transmitted.

An alternative system to the preceding is to instal the direction finding systems on the ships themselves. This method has many advantages over the preceding. It enables each ship to take bearings of any transmitting station in any part of the world, whereas the former system restricts the use of wireless navigation to certain regions. It enables many ships to determine their positions simultaneously, whereas the former system is comparatively slow. By this system every ship which has the apparatus installed can determine its position at any time. Again, the captain of a ship much prefers to trust bearings determined by himself or by personnel under his control. Again, a ship can determine its position without disclosing its whereabouts to any possible enemy, and it is thus the system which will be most applicable in war. It has certain difficulties, but these are completely out-weighed by the preceding advantages. The principal disadvantage is that it is necessary to instal the apparatus very carefully on each ship. Further, on metal ships, the ship itself has an influence on the bearings determined and corrections are necessary. The corrections to be applied can, however, be determined, and in certain cases the errors can be adjusted as in the case of the corrections and adjustments for the magnetic compass on steel ships. A typical error curve is shown in Fig. 6. Once such a

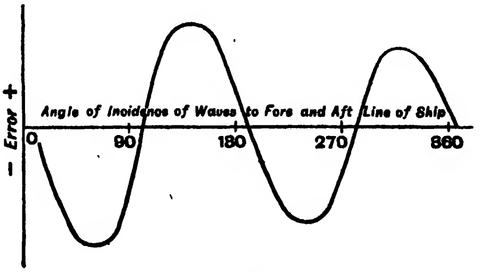

FIG. 6.
Typical Quadrantal Error Curve.

curve has been obtained allowance can be made when bearings have been taken.

There are two commercial companies in this country which instal direction finding apparatus on ships, and up to date about 200 ships have been fitted. Photographs are shown, illustrating a typical installation of the Marconi-Bellini-Tosi system, and an installation of the Radio Communication Company's Robinson system. Excellent results have been obtained with direction finding equipment on board

ships, and as time goes on, and as more and more experience is obtained by the navigators, results will be very much better, and equipment of this nature will become a standard installation for all ships.

A special but very important use of direction finders on ships is in cases such as the recent sinking of the "Trevessa." With direction finders on ships, and with simple transmitting apparatus in lifeboats in mid-ocean, searching ships can be directed straight to the lifeboats.

INSTALLATION ON AIRCRAFT.

On aircraft there are two methods of installing direction finding apparatus. The system most generally used is the Robinson system. In this case the coils are usually fixed into the wings, the main coil being placed in the fore and aft direction, and the auxiliary coil athwart-ships. The whole aeroplane is rotated in order to determine a bearing. This system is capable of being used by pilots themselves, and is particularly applicable to cases where definite routes are to be flown. For commercial flying, say, from London to Paris, or London to Amsterdam, with transmitting stations at both ends, the aeroplane can be flown continuously in the direction of its destination in each case. The operation is quite easy for the pilot, and after a little experience pilots get great confidence in this method. A test of the method was made sometime ago by having a ship transmitting at sea out of sight of land. An aeroplane started from Biggin Hill in Kent without any information, except that it had to find the ship which would transmit a particular signal every few minutes. The ship might have been in the English Channel or in the North Sea, but the observer immediately on getting into the air at Biggin Hill gave the pilot the correct course, and the aeroplane was flown straight to the ship, which was some 10 to 15 miles south of Brighton. The course followed from Biggin Hill to the ship was not deviated from in any degree. It should be noted that in this particular case visibility was very bad, and the pilot was within two miles of the ship before he observed it.

Rotating coils are sometimes fitted in aircraft, and one typical fitting is shown on the screen. In this case similar installation errors are obtained as in the case of ships, and it is necessary to determine these errors and to correct them or to allow for

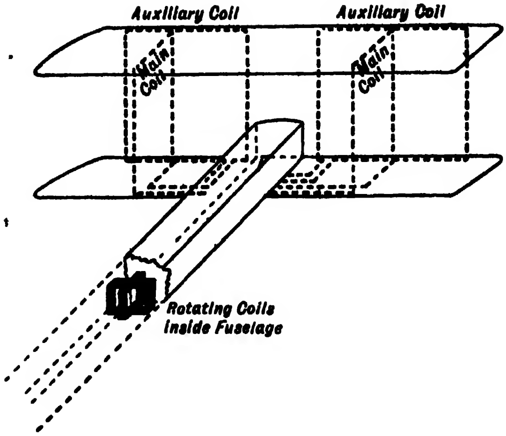

FIG. 7.
Method of fitting Fixed and Rotating Coils in an Aeroplane.

them. A typical flight in which these coils were used was made under the command of General Brancker, the navigator being Lt.-Col. Towler. This particular flight was made from Biggin Hill to Paris. The beacon stations used were Poldhu, Horsea, Nauen, Paris and Chelmsford. Position was determined from time to time, and it is to be noted that the aeroplane was above the clouds for practically the whole of the flight, the clouds on this particular day being very heavy. On the return flight General Brancker gave his instructions to the navigator with a view to testing out the system thoroughly, the navigator having no idea as to the destination of the flight. He was told to make for various points from time to time. Fig. 8 shows the course indicated by wireless navigation, and the actual course followed by the aeroplane as checked by the observer, who was told to observe the ground whenever he could see it. As a matter of fact he seldom saw the ground at all. It is to be noted that the navigator on this flight foretold the time of arrival at Paris and at Brighton to an exceptional degree of accuracy.

This system was also used by the American Naval Air Service when the N.C.4 was successful in crossing the Atlantic.

In this flight a particularly interesting example of the use of wireless direction-finding occurred shortly after the flying boat had left the Azores. The magnetic compass had become inoperative, with the result that the boat missed two of the ship stations placed for its guidance, and

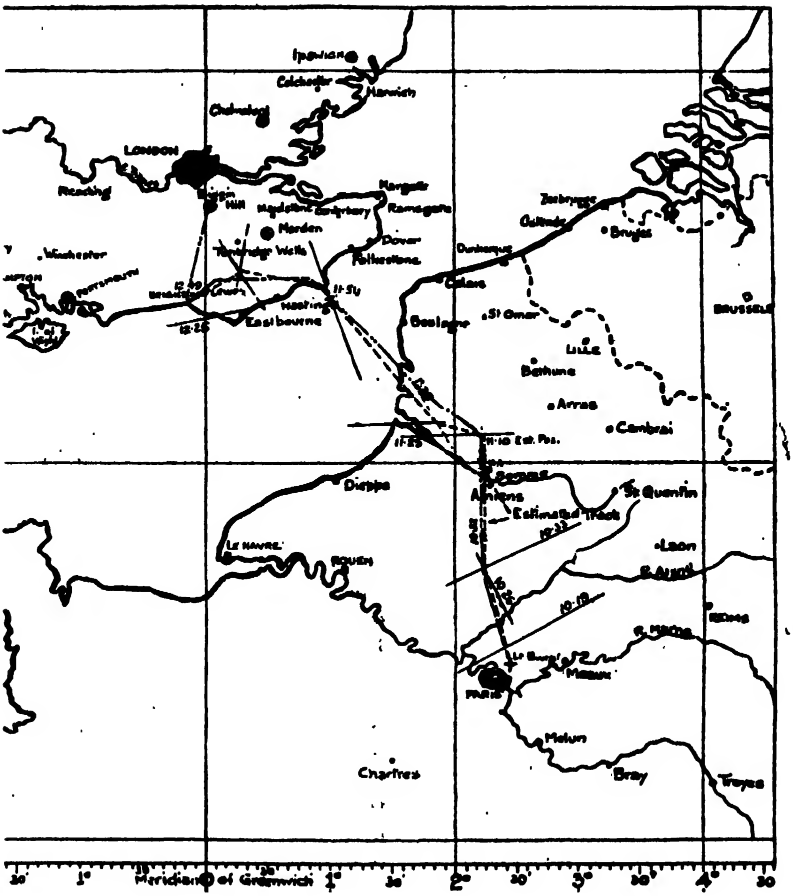

Fig. 8.

Flight above clouds from Paris to Brighton, using Wireless Navigation.

was in danger of becoming entirely lost. The direction of the next ship station was, however, obtained by the wireless direction finder, and by working on this direction the flying boat was enabled to proceed towards the ship and so regain its correct course.

Errors.

There has been considerable discussion from time to time as to whether bearings are subject to variable errors. It is established that under certain circumstance night errors are obtained, and these may reach considerable magnitude. These errors, fortunately, do not occur under all circumstances. A considerable amount of work has been carried out by the Radio Research Board in investigating these errors. The general conclusions which have been arrived at are that, outside the limit of accuracy of the instruments, where wireless waves travel completely over the sea, no errors occur either by night or day up to a distance of 100 miles. However, if waves have to travel for more than 15 or 20 miles over land, night errors are liable to occur. In cases where waves have hundreds of miles of land to traverse errors might be considerable. Recognising these facts, it is quite practicable to choose transmitting stations and general conditions so that bearings are reliable for navigational purposes.

The fact that the land has influence on bearings is borne out by a recent test made with aircraft. An aeroplane made a night flight between Croydon and Lympne. On the outward flight from Croydon to Lympne the aeroplane transmitted and asked for bearings. The ground direction finding stations found that there were

considerable night variations of bearings and thus the position of the aircraft could not be given with any great accuracy. On the return journey, however, wing coils were used on the aeroplane, and the pilot determined his own direction on Croydon transmitting station, this station using continuous wave transmission. No trace of night error was observed, and the pilot flew a straight course from Lympne to Croydon.

Directional Transmission.

Another method for effecting wireless navigation is the reverse of the preceding methods. This consists in transmitting directional signals from the shore or ground, and employing ordinary receiving apparatus on the ship or aircraft. The difference between such methods and those already described can be readily seen by an analogy with lighthouses. In one case bearings of a lighthouse can be taken by having the light shining equally in all directions, and the directional observation made by eye and compass on the ship. In the other case the light is actually directed in the form of a beam and is rotated uniformly. Work of this nature is of comparatively recent practical development. Two methods have been proposed.

Wireless Beam.

It has been found possible to concentrate wireless energy more or less in one direction by the use of reflectors or mirrors of a particular nature. This is only possible if the wavelength used is much shorter than ordinary commercial wavelengths. Marconi and Franklin have developed a system which makes use of wavelengths of the order of 6 to 10 metres. The aerial for this purpose is very small, consisting merely of a short unearthed wire with the transmitter inserted at the centre. This is placed vertically and is at the focus of a parabola. Around the surface of the parabola a number of vertical wires are placed, each wire being tuned to the same wavelength as the transmitting aerial. In this case the energy is reflected and concentrated into the form of a beam. A perfect beam such as is known in optics is not obtained for the reason that the wavelength is long compared with the dimensions of the mirror. The distribution of energy is shown in Fig. 9, from which it will be seen that along the axis of the mirror the largest percentage of the energy is concentrated. Behind the mirror an inappreciable amount of energy is transmitted. By the use of such a beam it is possible to obtain a navigational method. The whole transmitting system with its reflector is rotated uniformly once every two minutes. A distant observer will hear the signals only when the beam is pointing towards him or very nearly pointing towards him. The system is so arranged that a definite signal is transmitted on every point of the compass, and special marking signals between the points of the compass. Special cards are supplied for use with the signals, and it is only necessary for the observer on the ship to record the signals heard and to refer to this card for him to know from which point of the compass the signals are obtained, and thus his bearing is obtained directly. This method is installed

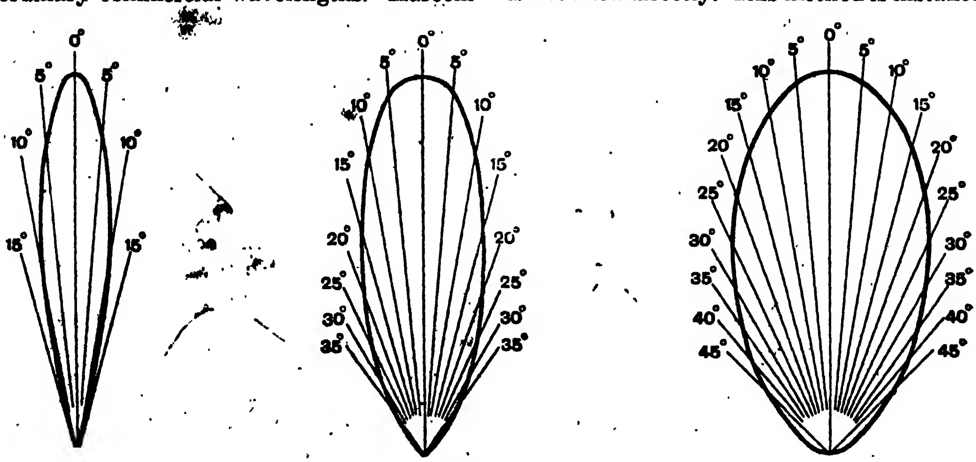

Fig. 9.

Polar Curves for Marconi Beam.

at Inchkeith in the Firth of Forth and has given satisfactory working. It has up to date not given very great range, the working range being about 10 miles.

This method has obvious advantages over the preceding methods. The principal advantage is that the technical work is concentrated at one spot and the observation of bearings can be done by unskilled personnel. It should be pointed out, however, that a special receiver for short wave reception is essential on the ships.

Rotating Loop Method.

Suppose that a loop is used as a transmitter, the reverse effects of reception are obtained. It is found that maximum signals are transmitted in the plane of the loop and zero signals at right angles to the loop. By rotating a loop of this nature uniformly, say once in 60 seconds, a distant observer will hear maxima and minima of the signal. Suppose further that a distinctive signal is transmitted when the plane of the loop is due north and south, and that a distant observer knows the time of rotation of the loop. If he can obtain the time of rotation from the north and south position to the position where he obtains maximum signals, or preferably minimum signals, he knows at once his bearing from the loop. For instance, suppose that the interval from the distinctive signal to the time of his maximum signal is 10 seconds, and that the time of rotation of the loop is 60 seconds, then his bearing is 10-60ths of 360°, *i.e.*, 60°.

This method has only been developed recently, and at first sight it would seem as if the range obtained would be very small as loops are supposed to be inefficient radiators. It is known that the amount of energy transmitted from a loop compared with that transmitted from an open aerial is small for the same aerial current. However, considerable assistance is obtained from the fact that it is possible from the same primary power to obtain much greater aerial currents in a loop than in an open aerial, and thus the contrast in ranges between loops and open aerials is not so bad as it would seem at first sight. This contrast is made more favourable for the loop by using shorter wavelengths. Loops have been developed for this purpose by the Wireless Department of the Royal Aircraft Establishment. A photograph of a loop is shown in Fig. 10.

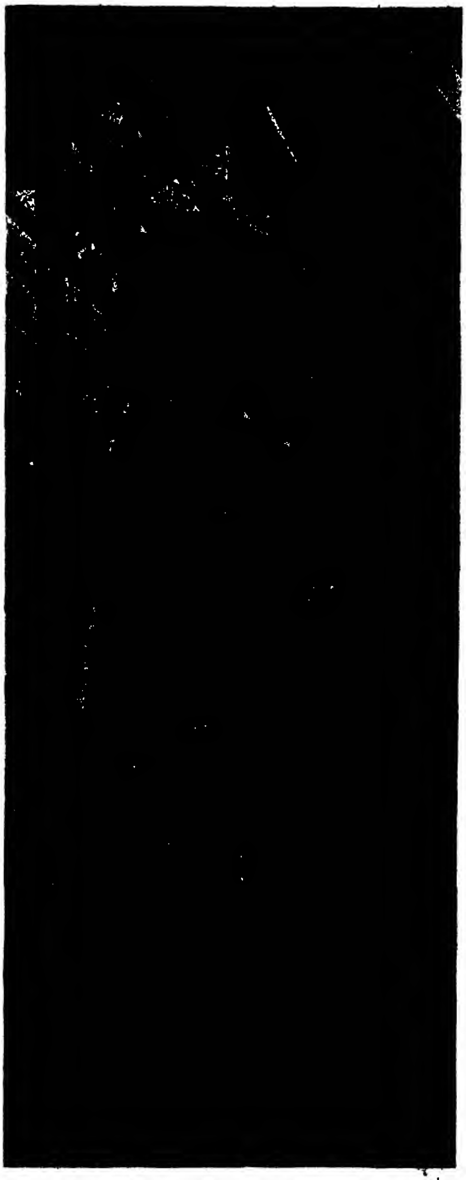

Fig. 10.

Rotating Loop Directional Transmitter.

The loop is square of 5ft. side, and consists of six turns. Continuous wave or interrupted C.W. transmission is employed. With a power of 500 watts it is possible on a wavelength of 500 metres to put 40 amperes into this loop, and this has given ranges, to an aerial on the ground, of 50 miles without the maximum having been obtained. Under much more strenuous conditions, *i.e.*, to aeroplanes, signals have been heard from this loop to a distance of

30 miles, so that this method of directional transmission appears exceedingly hopeful. Using crystal reception with an ordinary ship's aerial, it is estimated that under these conditions a distance of 12 miles can be obtained, but without much trouble it will be possible to use powers of 5 kilowatts and the range should increase sufficiently to be useful to crystal receivers up to a distance of 50 miles. It should be noted that it is quite possible to do this with ordinary commercial wavelengths, so that on a ship the ordinary wireless receiving apparatus can be used and all that a navigator requires in addition is an accurate stop-watch.

CONCLUSION.

Various methods for determining bearings have been described and examples of the use of these various methods have been given. Sufficient has been said to indicate that it is an absolute certainty that the era of wireless navigation is not far distant. Progress is rapid, difficulties are being overcome, and knowledge is sufficient at present to warrant universal adoption. Means for the dissemination of this knowledge is desired so that it may be brought within reach of every navigator.

All methods of wireless navigation have their uses. The tendency will be for the shore direction finding system to continue its use and probably to extend. However, the advantages of direction finders on ships and aircraft are so great that this method will ultimately be of more universal application. Directional transmission beacons on shore will also have great application, and in the future this method will have parallel use with that of the direction finders in the ships and aircraft.

In this country development work is being carried on by the Government, research work is being carried on by the Radio Research Board, and the application and some development is being carried on by various commercial companies. It is a big subject and involves considerable expense, and all credit is due to commercial companies for carrying on this development with, up to the present time, very little, if any, financial profit. There is need for great support by all Shipping Companies, the Board of Trade, Trinity House and Lloyds, so that at the earliest possible moment accidents at sea and in the air shall be minimised, and that there will be fewer cases heard of ships lost without trace.

DISCUSSION.

THE CHAIRMAN (ADMIRAL SIR HENRY JACKSON) said that the author had touched on the past, present, and future directional wireless as applied to navigation and other purposes. He had described the rapid development of the apparatus necessary for this work, particularly in this country during the stress of war, and he indicated that this country held a leading part at the end of the war. Apparently that had not been maintained, at any rate so far as maritime purposes were concerned—he thought it had been maintained so far as the Air Force was concerned—and at sea it had not been made use of to the extent to which many of them had hoped. He agreed with the author, but he was a little more sanguine with regard to the future. He had had a great many conversations with and requests from port authorities and shipping people, and others connected with navigation, concerning the reliability and accuracy of the apparatus. His reply was always the same. It was to the effect that direction finding by wireless could be relied upon to give accuracy within two degrees up to about 100 miles by day or night over sea, provided that the stations had been tested and if necessary corrected and calibrated before being brought into use. This was based on nearly four years' work carried out systematically by the Radio Research Board. The observation work had been carried out with the three types the author had described, on board ship, oversea, and overland, with waves varying in length from those used by the powerful commercial stations down to the shorter waves used mostly at sea. Under favourable conditions for good accuracy—namely, skilled observers, absolutely unbiassed in every respect as to the results obtained, well constructed apparatus carefully tested for errors, quiet surroundings, and frequent readings of the same transmitting station—the accuracy obtained was not necessarily greater than that obtained in the Battle of Jutland eight years ago. He repeated that the accuracy now was not greater than it was at the Battle of Jutland. The day before that action, in daylight, a change in the bearing of a German battleship, distant 300 miles, of 1½ deg. in two consecutive observations about one hour apart, convinced him that the German high sea fleet was on the move, and decided him to send out the British Grand Fleet to sea with all dispatch. This resulted in the Battle of Jutland. A change of 1½ deg. was enough. That was eight years ago. Had he been faced with the making of such a decision four years ago he would have hesitated. During those four years many reports indicated that these wireless observations were liable to inexplicable variations, especially at night. These had been described by the author and investigated by the Radio Research Board, and they were now

in a position to say where and up to what distance such errors did not make their appearance—that is to say, up to 100 miles at sea, day or night. Although they could not yet foretell their magnitude or assign their cause, the work was still proceeding hopefully, and some results were being gradually arrived at which might not be altogether hypothetical.

Well, it seemed to him highly probable that the wide circulation of the reports of the variation observed in direction-finding bearings during the last eight years had been one of the reasons why the mercantile marine had been so chary of adopting expensive apparatus on a large scale, and that they were only awaiting refutation by reliable authority of this reputed liability to error. The author had done much to show that this was a libel so far as work at sea was concerned, and also work in the air, and the speaker hoped that his work would bear fruit shortly. There were probably few localities in the world in which direction-finding navigation would be more useful than around the British Isles. The fact that airmen, without any exception, welcomed the aid of wireless was not surprising to the speaker. He was not an airman, but an old sailor, and he had served in sailing ships without steam and navigated them. He had served in such vessels in the Bay of Biscay in the winter, with no chance of observations for a week. In such circumstances the position got less reliable every day, and the sailor knew less and less where he was. Even then they were not so badly off as the airmen, because they did know the direction of the winds, thanks to their compass, whereas if the airman was above the clouds even this might not be known to him. Under such circumstances to pick up a wireless beacon might well be regarded as a gift from the gods. One of the reasons possibly why sailors had regarded this gift from the gods as a gift horse whose mouth they might well inspect, was due to the higher speed of present-day navigation, better means available for its accurate measurement, better charts and surveys, better tidal information, more efficient instruments of various kinds, and so forth. One of the things which might be acceptable was this radiating beacon, which certainly had, he hoped, a great future before it. It enabled the sailor to fix his position without having to instal other apparatus than that which he was obliged by law to carry. The speaker hoped to live to see a great many of these installed, especially in estuaries. It rested with the shipowners to decide which type of apparatus they would have. They could instal the Bellini-Tosi or Robinson systems if they liked to do so, only if they did so they ought to be rather careful, in taking the bearings of stations, not to use those too far inland, especially at night; or they might bring pressure to bear upon the Board of Trade to erect more wireless stations for directional finding work around the coasts. In New York Harbour, as the audience had seen, there were twenty stations or thereabouts for the one harbour, whereas in this country we had about half-a-dozen around the entire coast. Certainly we were not so far ahead as the Americans. It rested on the shipowners to press for further improvements. If these were not forthcoming they must utilise one of the systems of observation upon their own ships. He would conclude his remarks by congratulating the author very much upon his paper.

Colonel Lyster F. Blandy, D.S.O. (Air Ministry) congratulated the author upon a very clear and interesting paper. This was a most attractive subject, and perhaps the speaker was one of the first people to benefit by it. He had shared in one of the air trips which the author had described that evening. They went up on a very "dirty" day and got above the clouds, where it was beautiful sunshine. They went with great confidence, thanks to their wireless. The author had been working on this subject for a long time, and it was owing to his work that they were so confident on the occasion described. The work he had now put in on the radio-beacon was very valuable. In particular the speaker could appreciate its enormous value to the Air Force and in commercial aviation He felt that this matter was in very good hands.

Major B. Binyon (Radio Communication Co., Ltd.) joined with Colonel Blandy in congratulating the author on the very admirable manner in which he had dealt with the subject. It was a difficult subject to explain, and he had explained it in a most lucid manner. It was the speaker's good fortune to see some of Dr. Robinson's very early work in the development of this system, and to fly in machines fitted with his directional system. He was interested to learn that the early work with which they commenced experiments—namely, the fitting of wing coils—was one which he to-day believed would be of the greatest value in the directional guidance of aeroplanes on point-to-point flights. The author mentioned in his paper that aeroplanes fitted with wing coils would fly directly to the transmitting station, but the speaker thought he should mention that if there was very much drift that, of course, might not be actually the case. They might approach the distant station in a curved course. But, as a matter of fact in practice the operator, in taking frequent observations on the distant station, learned not to fly with his signal balanced —that is to say, with his two signals equal— but, learning what his drift was, he flew with the signal on one side slightly louder than the other. So he was able to steer, with a little experience, a perfectly straight course to the distant station. Since the war it had been his own good fortune to see much of the work of installation of Dr. Robinson's system on board ship. There were perhaps two principal difficulties to be faced One difficulty related to personnel, and the prejudice which seemed to exist against any innovation on the recognised system of navigation. Unfortunately, one often got criticism which he was afraid was both unscientific and quite un-

justifiable. Nevertheless, in spite of the prejudice which had been shown against the introduction of direction-finding it had made very great progress, particularly recently. There were, of course, other difficulties. One which the author had not mentioned was the particular characteristics of the ships themselves. On a large passenger vessel one had all kinds of electric disturbances to contend with. Some passenger vessels were fitted with an alternating buzzer to the cabin bells, which was liable to act as a radio-transmitter, and to cause an extraordinary amount of disturbance. On a big passenger vessel there were large numbers of fan motors on the upper deck working ventilating shafts, and these might have bad or defective commutators on which sparking occurred; these, again, were capable of producing considerable inductive noises. There were recognised methods of dealing with these things, but often the ship's electricians took exception to having condensers and the like fitted across their commutators to eliminate disturbing noises. The use of an electrostatic screen whcih was placed over the coil itself has been introduced by the Radio-Communication Co., and had helped very much in reducing the quadrantal errors which might be experienced from the rigging of the ship.

The position in which the direction finder was installed was another very important matter. They could only proceed on general rules, but it should be always installed for preference in the fore-and-aft line of the ship, and as far as possible should be symmetrical in relation to the funnels and other rigging, and away from large masses of asymmetrical metal, such as a large iron railing or a big water tank or anything of that sort. The author mentioned the automatic elimination of quadrantal error. This was a perfectly practicable proposition, but actually the speaker doubted whether there was very much to be gained by it. The author had shown a curve of the quadrantal error which was approximately a sine curve, but the speaker had never actually, among the many quadrantal curves on ships, seen one which was absolutely a true sine curve, and in any automatic balancing system which one might apply to the elimination of quadrantal error it was usually only the true sine curve which could be dealt with, and, therefore, there was always left some additional small error which had to be corrected for from a chart or table, and if one was going to use such a table at all, in his opinion the total quadrantal error might as well be applied from that table without troubling to apply merely a portion of it.

In connection with the beacons which the author had described, the speaker had a great belief that they would prove very valuable, particularly the system upon which the author himself had been working, in view of the fact that it did not require any special equipment on board the ship. On the other hand, they should not lose sight of the fact that some of the most important work of the ship's direction-finding lay in the ability of one ship to take a bearing upon another, and he would be very sorry to see the rapid development of a beacon tending to prevent the shipowner from himself installing a direction-finder on board ship, for the reason that the maximum safety of life at sea was not obtained unless a ship could also take a bearing upon another ship at sea, which necessitated installing a direction finder on board. In conclusion, he wished to pay a tribute to the admirable work which had been done under the Chairman's guidance by the Radio Research Board, and which had gone so far to prove the great value of wireless as an accurate method of direction-finding.

COMMANDER J. A. SLEE (Marconi Company) added his congratulations on an extremely interesting paper; the explanations given in the paper were extraordinarily lucid. He went on to refer to life-saving at sea. Nowadays a ship did not get into distress until after prolonged bad weather, when probably there had been no chance of making observations on the ship for some time, and, therefore, her position was likely to be quite wrong. There was one case which was of quite spectacular interest. A ship gave a position about 90 miles wrong; her position was picked up by a direction-finder on another ship; a boat was sent, which reached the ship when it was in a sinking condition, and the ship actually sunk before the rescue boat regained its own ship. Direction-finders on shore could not help in such cases, because they happened at sea, nowhere near the coast. That was one of the great arguments for direction-finders on ships. He thought he was not far wrong in saying that for most of the ships of the mercantile marine the figures were roughly as follows: Of British ships which carried wireless (about 3,000, that is, about half the mercantile marine of the world), 130 to 140 British ships carried direction-finders. (He was speaking of merchant ships only.) Of the ships of other nationalities which carried direction-finders, there were just over 40 American, just over 50 French, just about 40 Italian, so that the total number almost bore out the proportion of British ships to other ships—there were 3,000 British ships, and, roughly speaking, 3,000 ships of other nationalities, and about 130 ships of the British mercantile marine carried direction-finders, and about an equal number of ships under the flags of other nations did the same. Another thing was the use of wireless transmitting stations on land for direction-finding purposes. Trouble here arose if a point of land jutted out between the transmitting station and the ship. This generally caused an error, which reduced the accuracy of the bearings from first-class (within two degrees) to second class (within five degrees). The existing wireless stations were never built to serve as d.f. beacons, they were built for telegraphic communication, and a great many of them had their usefulness for direction-finding purposes rather curtailed by the land around them. There was pressing need for special stations erected expressly for the purpose of serving as beacons for d.f. work, and some

experimental stations were already in existence in this country. Facts and figures were being co[illegible]ated, and good work [illegible]

MR. J. HERBERT SCRUTTON (Chairman of Lloyd's Register) said he had no right to intervene in the discussion, because he was not a scientific man at all, and the only right he had to say anything was due to the fact that he made a voyage within the last month or so in a ship that had a direction-finder. The weather was extremely kind in the respect that it gave full opportunity for the most practical testing of the instrument. He came up from Gibraltar in one of the Orient boats, and they passed Cape St. Vincent the first night, Finisterre the second night, and Ushant the third night. No observation was obtained on the voyage, but they made the Eddystone right ahead. He overheard one of the crew say to another, "Nobody in the world but our old man could have done that." Personally he had not any doubt that it was the direction-finder which should have received the compliment. Of course, the captain had his soundings, he got his dead reckoning, he got the broad angle of which the author had spoken, and he got his position with practical certainty. But the fact was that these ships, apart from the direction-finder, very often did not know where they were. Admiral Sims, when the American Fleet was over here, had the remark made to him, "I see an American battleship got lost in the North Sea." "Yes," he replied, "whenever they go out they get lost." Looking at the losses which did occur, it was obvious that unless the captain had the opportunity of taking sights in the ordinary way he was very soon out of his position, and quite far enough to put him into trouble. As a ship-owner the direction-finder struck him as the most extraordinary advance that he had ever seen in his experience. With this aid a man coming towards the land in a fog was able to fix his position within a mile or two. They could hardly imagine the relief this must be to the navigator. Any who had stood on the bridge of a big steamer was aware of its atmosphere of anxiety, and the direction-finder was of the most wonderful assistance, used intelligently, and in combination with all the other aids to navigation. Of course, shipping authorities were not very willing to take up a new thing. Losses at sea were now few and far between. Moreover, shipowners were not very prosperous at present, and the natural British conservatism also operated. The speaker was "all out" for putting the direction-finders on board the ship instead of the ships taking the bearings given by the shore stations. The trouble with wireless would be that there was too much talking. If the instrument could be used without adding to the disturbances already existing, it would be very great thing. In the wireless cabin they had A, B, and C all talking at once. The operator, of course, was able to distinguish, but manifestly, with the number of ships engaged in overseas trade, if one could get this effect without making any further disturbance it would be of enormous advantage.

GENERAL SIR WILLIAM S. BRANCKER, K.C.B. (Air Ministry) sent a letter, which was read by Colonel Blandy. After expressing his regret at being unable to attend Dr. Robinson's lecture, he wrote:

"As long ago as 1917, as a member of the first Civil Air Transport Committee which was convened that year, I ventured to say that I considered wireless communication to be the life-blood of air navigation. I have [illegible] cause to alter that opinion; useful and reliable as the compass is, it cannot solve the problems of navigation above the clouds, and it is above the clouds that most aerial navigation will take place in the future.

"Personally, I favour what I have sometimes described as the 'lighthouse' system for the future—that is, the provision of a system of wireless stations on the ground which will emit periodic distinctive signals for the benefit of all aircraft in the air, the calculations and plotting necessary being carried out by the crew of the aircraft; even with a crew limited to pilot and navigator this should be possible, with improved apparatus and a little more room and comfort in the cockpit than are provided in existing aircraft. Air navigation across the Channel has already been revolutionised by the provision of wireless telephony, and this is only the beginning of things!

"I congratulate Dr. Robinson on his paper, which I have read with very great interest."

M. PIERRE SCHILOWSKY (President de la Société Gyroscopique et de Mécanique scientifique) pleaded that in further practical improvements with regard to aviation the psychology of the pilot should be borne in mind, more particularly in the direction of arriving at some method of visual radio-telegraphy, such as the wireless compass. The great embarrassment of the pilot in a fog was his total inability to use his visual perception in regard to the instruments by which he steered his course. He pleaded that the brains of the technicians should be directed to elaborating some instruments of visual wireless. He admitted that the question was full of difficulties.

CAPTAIN COLIN NICHOLSON, R.D., R.N.R. (Branch Secretary, Mercantile Marine Service Association), felt sure that most of those present knew more of the subject under discussion than he did; but as a navigator of the old school, he would like to say how much the lecture of Dr. Robinson had appealed to him.

Mr. Scrutton had referred to a recent trip of his, where it was alleged that a good landfall had been made in an Orient liner, which he (Mr. Scrutton) had no doubt should be ascribed to the wireless bearings received by the Commander. Being an ex-Commander in that Line himself, and having "made" the Eddystone many times

under both good and bad conditions, he could bring forward an illustration. Some years ago, being at that time in command of an Orient steamer, a pilot was picked up off Plymouth after a bad trip across the Bay. The pilot's first information was that a large steamer was ashore—the s.s. "Suevic";—followed quickly by the remark that there was also another one ashore—the s.s. "Jebba." By good luck, or, perhaps he might be permitted to say, by good navigation, the Orient steamer was afloat, and duly arrived at Plymouth. Now, had the captains of those two steamers been able to ascertain their position by wireless directional bearings, the probability is that there would have been two casualties less in Lloyd's List the following day.

The best navigators would be the first to adopt any aid to safe navigation: and as the transmission of wireless directional bearings became less and less liable to error—Dr. Robinson had shown how small such errors now were—so navigators would make confident use of them.

Looking round at the wonderful advances recently made, and yet going on, it was one of the speaker's regrets that, having practically ended his sea career, he could not participate in the facilities now being introduced and perfected. His Society, the Mercantile Marine Service Association, had from the first kept a watchful eye on developments, and had, in fact, for some time been urging the authorities to establish more Wireless Direction-Finding Stations round the coast of the United Kingdom.

In conclusion, he thanked the lecturer for his very instructive lecture and interesting illustrative experiments.

Captain Barnard spoke from the point of view of the airman in the commercial air service. If the airman flew below the clouds he was in some danger, and with low-lying clouds the danger was obviously greater; if above the clouds he was more or less safe. In commercial aircraft they had all sorts of things laid down that they had to do by wireless, to report their positions, to get weather reports, and so on, and in order to get this information they had to listen in on a distant wavelength, but it was not practicable for them to obtain all this information on one aerial and to listen in to all sorts of buzzers on another aerial. In commercial aviation they had to utilize wireless to the same extent as they utilized machines and engines, they all went together to make one more or less efficient whole. He was afraid that until such time as they could have machines carrying about fifty passengers, with crew in proportion, it was not possible to go in for these idealistic schemes. They must get on with it as best they could.

Captain F. Tymms (Air Ministry) spoke of the degree of accuracy possible in wireless navigation from the point of view of detecting changes in the wind. An error of one degree in a bearing, at a range of 1,000 miles, would result in an error in position of something like two miles. To detect a change in wind one had to calculate the wind from two observations of position. If both these observations were incorrect by two miles—and the navigator had to suppose that such error might exist—and the errors were not in the same direction, the total error might be as much as four miles. This error occurred in a time interval of 10 to 15 minutes—consequently the error in the wind determination might be in the neighbourhood of 20 miles an hour. Although the present results were of great value, therefore, he thought it very desirable for aerial navigation that the wireless experts should still strive for greater accuracy. With regard to directional transmission he wished to emphasise the advantage gained by the elimination of quadrantal error and compass error to which the author had alluded. Compass error on some machines was still a serious factor.

Lieut.-Colonel H. F. Towler said that from his own experience with regard to the standard of accuracy given by a ships' company for visual bearings, he thought there could be no doubt that the accuracy of direction finding was quite good enough for ordinary sea navigation if applied with intelligence.

The Chairman, in calling upon the author to reply, said that he did not wish his remarks to be misunderstood—he had nothing to say whatever against putting in direction-finders on board ship.

Dr. Robinson, in reply, said that his paper had escaped with very slight criticism, but the discussion had shown that interest in wireless navigation was increasing, and that was the object of his paper. He was much interested in the facts regarding marine navigation which had been brought forward. He had intended to give himself quite a number of such facts, but everything could not be included within the compass of a paper. With regard to M. Schilowsky's suggestion about visual radio-telegraphy, this was a question which not merely the speaker but everyone who had considered wireless telegraphy had thought about. Undoubtedly in the future one would get on towards visual radio-goniometry—in other words, the actual wireless compass. But there was a long way to go, a large number of wireless problems had yet to be solved before that point was reached. He thought that wireless telegraphy would go a great deal further once certain conditions in actual wireless technique had been satisfied. The application to the wireless compass would at some time in the future be easy, and the settlement of that problem would settle a number of other large problems in wireless.

The other point which required some attention was with regard to wing coils. Captain Barnard was under a misapprehension if he assumed that there was any reason at all why he should not also use wing coils for normal reception. His experience had been the experience of all pilots ever since aviation began. The object of the people who designed gadgets was to make them

as simple as possible. His own deduction as to these coils was made purely with the object of assisting pilots, and they did appear to be the very best thing for pilots' use. The question which Captain Tymms had brought forward bore on the same subject. He had touched upon one of the greatest problems which had to be solved; the speaker would like to solve it, it had not been solved up to the present. On this matter of landing in fogs, accuracy was not sufficient, and quite a number of ideas were in being for further assisting the pilot, but that was about as far as they could go at the present time. He wished to add how honoured he felt that Sir Henry Jackson had taken the chair at that meeting.

The Chairman said that it was a great pleasure to support Dr. Robinson in view of the long-continued support which Dr. Robinson had given him on the Radio Research Board. He asked the audience to express its thanks to Dr. Robinson for a very interesting paper.

The vote of thanks was accorded unanimously, and the proceedings terminated.

Lieut.-Colonel H. F. Towler writes as follows: I understand Captain Tymms to say that an error in position, due to a 1° error in bearing at 100 miles, of say 2 miles, may in certain circumstances cause the navigator to calculate a wind some 20 miles in error.

These circumstances must be allowing for a run of only six minutes between the two fixes from which the calculation is made.

Similarly, if it were possible to allow a run of only three minutes between fixes an error of 40 miles in the wind could be created.

This latter case is obviously ludicrous. Obviously every form of navigation is striving for increased accuracy, but in the present state of the science an error of two miles would frequently occur in most of the older and well recognised forms.

It is, therefore, necessary that in any form of "chart work" the navigator should recognise the necessity for allowing a reasonably long run between observations to avoid creating artificial errors.

The principal object of the navigator is to take his ship or aeroplane to her destination; if he bases his alterations of course on observations half-an hour apart, and experiences the maximum error o-f two miles in the fix, his error in the next hour's run would be between four and eight miles only. In practice he would take further observations, and any accumulation of error would, therefore, be avoided. It is wiser to avoid the habit of regarding the aerial navigator's principal duty as that of determining the force and direction of the wind. The wind *can* be determined from a series of observations plotted in the course of a long flight. But the first requirement is to plot a series of fixes on the chart which enable the required track to be followed as closely as possible.

OBITUARY.

Sir Frederick William Duke, G.C.I.E., K.C.S.I.—Sir William Duke, Permanent Under-Secretary of State for India, who died very suddenly on the 11th June, in his 61st year, had been a Fellow of the Royal Society of Arts since 1915. He always took a keen interest in the Society's work, had been a member of the Committee of the Indian Section since 1915, and was Chairman of that Committee and a member of the Council from 1916 to 1920. Both in the Committee and in the Council his experience, his wide general knowledge, and his fertility of suggestion were of great value and his relinquishment of the Chairmanship, which was necessitated by the pressure of official duties, was sincerely regretted by his colleagues.

Sir William Duke was the son of the Rev. William Duke, D.D., Minister of the Parish Church of St. Vigeans, Forfarshire. Educated at Arbroath High School, University College, London, and "Wren's" he passed the open competition for the Indian Civil Service in 1882 and two years later was posted to Bengal, in which province the whole of his career in India was passed. He never coveted the limelight of high office and, though his admirable work as a District Officer and subsequently as a Commissioner was fully realised locally, it was not till 1908 that the then Lieutenant-Governor, Sir Edward Baker, selected him as his Chief Secretary. In 1910, an Executive Council was created in Bengal and Duke became one of its members. In the following year he acted as Lieutenant-Governor in the absence on leave of Sir Edward Baker and when, six months later, Sir Edward retired without returning to India, Duke remained at the head of the province till Bengal was made a Governorship. He then became the Senior Member of Lord Carmichaels Council. In 1914 he was appointed a Member of the Council of India. and in that capacity, in 1917, he accompanied the Secretary of State, Mr. Montagu, to India There, and afterwards in England, he took a leading part in the discussions which ended in the framing of the Montagu-Chelmsford Report and the passing of the Government of India Act of 1919 by which the existing constitution of British India was established. At the end of 1919 he succeeded Sir Thomas Holderness as Permanent Under-Secretary of State. The duties of this post during the introduction of the new arrangement have been exceptionally arduous and Duke till his death devoted to them his talents, his industry, his calm and sympathetic judgment, and his remarkable power of overcoming difficulties with a sympathetic and unfailing courtesy which secured for him the highest appreciation. The work of his later years was recognised officially by the conferment on him of the C.S.I. in 1910, the K.C.I.E. in 1911, the K.C.S.I. in 1915, and the G.C.I.E. in 1918, and personally by the regard and affection of all who had the privilege of working with him. He obtained the high honour

of election in 1922 to the Athenæum Club under Rule ii. Sir William Duke was a man of singularly unassuming character to whom distinction and popularity came unsought. In him, it is no exaggeration to say that an able and devoted public servant has been lost to India and a trusted and valued friend to all who knew him, whether in official or private life.

NOTES ON BOOKS.

PEASANT ART IN SWITZERLAND. By Daniel Baud-Bovy. Translated into English by Arthur Palliser. London: "The Studio," Ltd.

This volume is the fifth of an excellent series on Peasant Art published by The Studio, the other four dealing with Sweden, Lapland and Iceland, with Austria-Hungary, Italy and Russia. The author has selected for description the Lötschenthal, a remote valley hidden in a fold of the Alps, the only means of access to which is a single mule track. The peasant art to be found here is very characteristic. After a brief introduction dealing with the nature and surroundings of the valley, and the artistic instincts of the inhabitants, M. Baud-Bovy proceeds to discuss the various types of peasant's house, which he classifies as Celto-Roman, Italo-Roman, Rheto-Roman, "Plateau" house, and chalet. Some charming illustrations are given of the various types, showing characteristic features of both exteriors and interiors. This section is followed by a very interesting chapter on woodwork. Some of the illustrations here are admirable and show the Swiss peasant as a woodcarver of a very high order. Nor is the section on metalwork less interesting. The Swiss blacksmith and pewterer are very accomplished craftsmen, and one or two of the inn signs illustrated are beautiful and delicate pieces of ironwork.

Other sections deal with costumes, textiles, and pottery and glassware.

The illustrations, of which there are no fewer than 430, are admirably selected and reproduced, and they give a very adequate representation of the qualities of the peasant art of Switzerland.

CORRESPONDENCE.

LONDON TRAFFIC.

The paper on London traffic (reported in the *Journal* of May 16th) by Sir Lynden Macassey and the discussion which followed is most interesting.

There are means of expediting traffic that were not mentioned, one of which is the use of colour light signals, interlocking the complete area subject to congestion.

It is apparent that if traffic is timed properly, it is possible for two continuous streams to be operated over an intersection without cessation. However, the human element makes it next to impossible so to time it, and it is left for us to devise means by which we may approach the ideal. By the use of interlocked signals, the traffic is separated into "periods" which permits it to run a considerable distance without inteference, the time period being regulated according to the traffic density.

Another traffic question that is important and should be taken up, is the indiscriminate use of the red light.

We are trained from infancy that red is a symbol of danger and yet we find it used where no such indication is intended, for example, on fire escapes in public places, on stairs, exits, etc. The use of the red light on the rear of automobiles has been the cause of many accidents; the red light of a drawbridge having been sometimes taken for that of a standing auto. Minor obstructions on the road side guarded by a red light which can be passed with safety and an absolute obstruction across the highway, such as an excavation, are often indicated by the same red light. My thought is that the red light should be used only to indicate danger, stop, and stay, and that a caution signal (yellow) should be used on all such obstructions as may be passed, and of course, green to denote safety, clear, or proceed. This question is now being studied by the traffic organisations of the United States. The Railways on this side have standardised the use of these three colours.

J. R. W. AMBROSE.

The Toronto Terminals Railway Company
Engineering Department,
Toronto, Ont.

AGRICULTURAL INDUSTRY OF PORTUGAL.

According to the Report on the trade, industries and economic conditions in Portugal, by H.M. Consul at Lisbon, agriculture is the basic industry of Portugal, occupying not less than 60 per cent. of the population. With a sunny but comparatively moist climate, the country is exceptionally fertile; almost the entire surface is capable of being utilised. More than a third is still awaiting exploitation, mainly for lack of transport facilities. In many districts produce cannot be distributed nor fertilisers supplied. It is estimated that 20,000 tons of additional fertilisers are required in the Alemtejo alone. An improved system of roads and railways, accompanied by extensive irrigation and the general adoption of modern farming methods, would easily increase the present results at least 100 per cent. As regards irrigation, a scheme exists for opening a canal from the river Sorraia, a tributary of the Tagus, which would irrigate 100,000 acres of the best land in the Alemtejo. The methods in use, except on some of the larger farms in the south, are reminiscent of the days when Portugal was a Roman province. Farming depends excessively on hand labour, of which there is a shortage. The conditions are aggravated in the frontier districts by the unfavourable comparison of escudo and peseta wages, a considerable number of labourers having crossed into Spain. At the same time, agricultural

wages have more than kept pace with the depreciation of the escudo and the consequent increase in the cost of living. A farm hand who ten years ago would have been satisfied to earn 40 centavos a day now gets 10 escudos, equivalent to considerably more than the difference in the cost of living. Labour is, however, still cheap, and agriculture continues to be the chief source of national wealth. The most valuable crop is *wheat*, which is grown largely in the Alemtejo region above mentioned, once the "granary of the Roman Empire." The average yield of this crop is six to seven quarters an acre, but in some places nearly half a ton an acre has been obtained. The total wheat harvest averages 230,000 tons a year. Only once is it recorded to have supplied the whole of the national consumption, namely, in 1911, when it reached 322,000 tons. On that occasion there was a margin of 30,000 tons, but as a rule wheat is one of Portugal's largest imports. The yield in 1923 was one of the largest on record (approximately 453,994,820 litres), but owing to the disinclination of the farmer to adhere to official prices the Government authorized the importation of 50,000 tons of wheat in the interests of the public. As far as possible, it is the policy of the Government to encourage wheat growing. In some parts vineyards have been converted for this purpose.

Maize is produced in large quantities, all consumed in the country. The production in 1923 was 289,000 tons. Other cereals grown on an extensive scale include 130,000 tons of *rye* and 125,000 tons of *oats* and *barley*. About 200,000 tons of *potatoes* are produced, besides 60,000 tons of *beans* and 15,000 tons of *rice*. The latter is a declining product. Seed potatoes are imported from France and England in sailing vessels which return with fish and salt.

Much Portuguese fruit goes to England, especially *figs*, *almonds*, and *carob beans* from the Algarve, but the trade might be largely increased by proper cultivation. The annual value of the three crops named exceeds £500,000.

The *grapes* from which port wine is made are grown in the Douro Valley, though the brandy required to give it character comes from farther South between Santarem and Leiria. Table wines are produced over a wide area and exported to Brazil and the Portuguese Colonies and also to France. Attempts have been made to register the name Lisbon wine, but competing interests have thus far effectually opposed the movement. 100,000 hands are engaged in the vineyards. The vintage in 1923 was disappointing in the port region, being only moderate after holding out exceptional promise. Elsewhere the results were above the average.

Portugal follows Italy and Spain as the third *olive*-producing country in the world. Olive trees occupy an acreage exceeding three quarters of a million. The annual production is half a million hectolitres, valued at £1,500,000. Ten thousand presses are in use.

The yield of *cork* varies between 50,000 and 75,000 tons, valued at approximately £1,000,000. The area covered is about the same as the area under olive trees. There are nearly 100 cork factories, some of the most important being British.

The number of *livestock* is estimated at nearly 6,000,000, the same as the population. Sheep comprise more than half or just under 3,000,000; while the rest in order of number are pigs and goats—slightly under 1,000,000 each—cattle, donkeys, horses and mules.

Portugal being primarily an agricultural country, there is both a large actual demand and a still larger potential demand for agricultural machinery. This is a trade in which Great Britain has not recovered her pre-war position. The United States gets most of the orders for reapers and binders. Threshing machines are also bought chiefly from the States, though English threshers have not lost their good name. Germany has temporarily captured the market for motor ploughs with two cheap handy machines specially suited to the hard Portuguese soils, which require that in order to keep the nose of the ploughshare to the ground the main weight should be well forward.

In order to sell agricultural machinery in Portugal, it is necessary to make a study of the conditions of the soil and to demonstrate locally. By this method some 40 Holt caterpillar tractors have been sold—mostly in the south where the farms are largest. The average Portuguese farmer will not go out of his way to find the best machine—or any machine for the matter of that. He is content to go on in the old way. But if the merits of a machine are actually set before his eyes, he is always a potential buyer.

SOUTH AFRICAN OSTRICH FEATHER INDUSTRY.

The ostrich feather industry in South Africa dates from the year 1865, and during the course of the past 60 years has done much to enrich, and also to advertise, the country. However, an industry devoted to the production of an article of fashion is subject to great fluctuations, and consequently the industry has had many ups and downs. The market flourished during the late seventies and early eighties, so much so that in 1886 a shipment of ostriches was made from Cape Town to southern California, where the industry was first established in the United States. A serious depression occurred in feathers in the early nineties, but they revived in the later nineties. From 1905 the industry made great progress and reached its peak in 1913, when the value of ostrich feathers exported from South Africa was nearly £3,000,000.

Shortly after the commencement of the World War the industry suffered a depression from which it might have recovered if hostilities had not continued. Instead the trade steadily declined until 1918, when the value of feathers exported only reached about £80,000, less than it was 50 years earlier. A comparatively slight revival has taken

place since 1918. The exportation of feathers in 1922 amounted to nearly £400,000, but this amount is far below the 1913 figure.

Owing to the fact that there are at present only 200,000 ostriches in the country, as compared with almost 1,000,000 in 1913, the industry is much handicapped. This tremendous decrease in the number of ostriches is attributable, writes the United States Vice-Consul at Port Elizabeth, to (1) deliberate slaughter of birds during the war because they were not worth their keep, (2) mortality through neglect, and (3) the stoppage of breeding. The decline in the ostrich-feather industry seems to be due principally to a change of fashion, but another reason given is the increased use of motor-cars, the wind from motoring having a very destructive effect on ostrich feathers It is hoped, however, that the more common use of closed cars will obviate this objection.

UNDEVELOPED NATURAL RESOURCES OF QUINTANA ROO (MEXICO).

A territory in Mexico possessing vast unexploited natural resources lies but 600 miles south of New Orleans. This 18,000 square miles of land is practically unknown and very sparsely populated. It extends nearly 300 miles from north to south and has a coast line of probably twice that length. It is known as the Territory of Quintana Roo and comprises the eastern part of the peninsula of Yucatan. The Government is territorial, the capital being Santa Cruz de Bravo (a town of about 2,500 residents midway down the Mexican Gulf coast); most of the remainder of the 9,000 people live in the villages of Payo Obispo, Cozumel and Bacalar.

Information as to the interior is scanty, and data obtained by the United States Consul at Progreso during a six-year residence on the peninsula has been secured chiefly from extractors of chicle gum, prospectors, and archæologists, the latter investigating the many ruins of once populous Maya cities. Reports are to the effect that, unlike other sections of the peninsula, Quintana Roo has several ranges of hills, about nine inland lakes, and a few short rivers flowing to the eastern coast.

The western portion is said to contain extensive green rolling pampas, the interior to be densely forested with valuable tropical woods, and the coast to abound in game and in food fish. The soil is claimed to be suitable for the production of maize, cotton, beans, coffee, indigo, rubber, sugar cane, tobacco, sweet potatoes, pepper, vanilla, henequen, tropical fruits, etc.

Modern transportation facilities are non-existent, but the advent recently of the first caterpillar tractor into the forests of Quintana Roo may initiate development of the resources of this reputedly rich and unexplored section.

RUBBER PRODUCTION OF ECUADOR.

Various trees, vines, shrubs, and herbs producing crude rubber, and indigenous to Ecuador, are found in a wide expanse of country at an elevation varying from 200 to 4,000 feet and with a mean temperature of 26° C. Such conditions exist in the Provinces of El Oro, Guayas, Esmeraldas; portions of Manabi, Los Rios, and Chimborazo; and the immense territory known as the Province of El Oriente, which is on the East side of the Andes at the headwaters of the Amazon River.

The tree producing most of the rubber in Ecuador writes the United States Consul-General at Guayaquil, is supposed to be the *Castilloa elastica*, which grows abundantly in its wild state; another form closely related to it is the *Tuna*. When 6 years of age the tree flowers during the months of November and December. A vine which eventually develops into a tree known locally as "matapalo" (*Ficus* sp.) also produces rubber, together with numerous other plants, including species of the genera *Apocynum* and *Brosimum*, yielding a milky juice which coagulates into a gum having the qualities of rubber.

There are a number of rubber plantations in the Balzar and Tenguel districts, as well as in the Provinces of Manabi and Esmeraldas, containing more than a million trees. These plantations are the result of a law passed in 1902 and amended in 1904, providing for a premium or bounty for each rubber tree planted in the Republic after that date, payable when the trees should attain an age of 5 years or more; however, no payments have ever been made.

The plants may be propagated from cuttings or seeds, the latter being the principal source. The method employed to start plantations is to cut out most of the forest trees, leaving a sufficient number for shade, and plant bananas in the open space. When the banana plants are a few feet high, the rubber plants are placed between them, which in six months are about 7 feet high and covered with large leaves, the growth being rapid..

The commercial grades of crude rubber known in Ecuador are : Andullo maroma and andullo duro (or hojas). Owing to the low price of rubber a few years ago its production ceased, as the returns were insufficient to cover the cost of gathering and marketing.

The Indians collect the latex and reduce it to crude rubber which is delivered to the exporting centres, whence it is shipped to foreign markets. The crude rubber is transported from the interior to the ports on the backs of men and mules or by canoe.

MEETING OF THE SOCIETY.

INDIAN SECTION.

MONDAY, JUNE 30, at 4.30 o'clock.—J. C. FRENCH, I.C.S. "The Art of the Pal Empire in Bengal." THE RIGHT HON. THE EARL OF RONALDSHAY, G.C.S.I., G.C.I.E., will preside.

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FRIDAY, JUNE 27, 1924.

All communications for the Society should be addressed to the Secretary, John Street, [illegible]

NOTICES.

NEXT WEEK.

MONDAY, JUNE 30th, at 4.30 o'clock. (Indian Section.) J. C. FRENCH, I.C.S., "The Art of the Pal Empire in Bengal." THE RIGHT HON. THE EARL OF RONALDSHAY, G.C.S.I., G.C.I.E., will preside.

ANNUAL GENERAL MEETING.

WEDNESDAY, JUNE 25TH, 1924. LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair. The One-hundred-and-Seventieth Annual General Meeting of the Society was held for the purpose of receiving the Council's Report, and the Financial Statement for 1923, and also for the Election of Officers and new Fellows.

A full report of the Meeting will be published in the next issue of the *Journal.*

COUNCIL.

A meeting of the Council was held on Monday, June 16th. Present:—

Lord Askwith, K.C.B., K.C., D.C.L., in the Chair; Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Lord Blyth; Mr. A. Chaston Chapman, F.R.S.; Mr. Edward Dent, M.A.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Sir Herbert Jackson, K.B.E., F.R.S.; Major Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; Mr. James Swinburne, F.R.S.; Mr. Alan A. Campbell Swinton, F.R.S.; Mr. Carmichael Thomas; Dr. J. Augustus Voelcker, M.A., Ph.D.; and Sir Frank Warner, K.B.E.; with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

Preparation of the balloting list for the new Council was completed.

The Annual Report of the Council was considered, amended and approved.

The Financial Statement for 1923 was laid on the Table.

Preliminary consideration was given to the arrangements for Lectures and Papers in Session 1924-5.

Other formal business was transacted.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

MONDAY, JUNE 2nd, 1924.

THE RIGHT HON. VISCOUNT MILNER, K.G., G.C.B., G.C.M.G., in the Chair.

The paper read was:—

THE MANDATE SYSTEM AND THE BRITISH MANDATES.

By THE RT. HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O.,

British Member, Permanent Mandates Commission, League of Nations.

I welcome the opportunity afforded to me to-day to address you on the subject of the Mandatory principle and the British Mandates, for though the British Empire holds nine out of the fourteen Mandates, and has incurred responsibility for an additional million square miles, and some eight million people, less attention seems to have been devoted in this country to the theory and application of this novel experiment in International Law, and its present and future problems, than has been evoked in the United States, which holds no Mandate at all.

ORIGIN.

Let me first recall to your minds the conditions under which the system originated. The representatives of the victorious Allies, assembled in Paris in 1919, had to decide what was to be done with the former overseas possessions of Germany and Turkey. Many hundreds of millions of debt had been in-

curred in their conquest, and thousands of lives had been the price of victory in these outlying theatres of the Great War—especially in Palestine, Iraq, and East Africa. There is no doubt that on these grounds alone any idea of restitution to their former rulers would have been scouted by most—probably by all—as an insane proposal. Moreover, their misrule had been loudly denounced, and it was strongly felt that to expose to their vengeance the people who had espoused our cause in the War would be an act of unthinkable baseness. Yet it must be confessed with regret, that when the United States (which had never been at war with Turkey) refused the Mandate for Armenia, it was restored to that country. German writers, like Zimmermann in his "Mittel Europa," had indulged in visions of a great Black Army of well-trained African soldiers which should aid in world domination, and of ports in every sea which should serve as bases for submarines. Wireless installations like that in Togoland—one of the most powerful in the world—would ensure her communications with every base in time of war, and be a constant menace to the command of the seas.

On the other hand, President Wilson, who exercised great influence, not only as the representative of the United States, but as the only Head of a State present at the Conference, stood committed to the "Fourteen Points," which he had advocated as the only true basis of a just peace, and the Germans indeed maintained that the Armistice had in a general sense been based upon them. All the world at that time thought that the President spoke in the name of the United States, which would be a party to the treaty. He had enunciated the doctrine of "the Self-determination of small States," in spite of the protests, as we have since learned, of his Secretary of State, Mr. Lansing, who foresaw the false and impracticable visions it might create in ignorant communities. He had insisted, moreover, on the principle of "No Annexations," and indeed (as Mr. Quincy Wright points out in an American journal), the pre-Armistice agreement of November 5, 1918, had clearly repudiated annexation. Yet probably, the majority of the victors were in favour of this course, including France, Japan, and the three Dominions. Even General Smuts, who claims credit as an advocate of the Mandate principle, did not propose to extend it to the C Mandates. So strong indeed was the demand of the Dominions that they should acquire complete possession of the conquered territories contiguous to their own in S.W. Africa and the Pacific, that in the event it was with difficulty that a form of Mandate was devised, which General Smuts described as "annexation in all but the name,"—and American and Japanese writers have used the same terms.

How were these demands to be reconciled to the theories of "Self-determination" and "No Annexations," and to the secret treaties and understandings which had been made in the exigencies of the War, and to pre-Armistice protestations? The British public was deeply stirred by the accounts of German misrule and cruelty in Africa, and by Turkish massacres in Armenia, but British statesmen were not anxious to add new territories to the Empire, or to incur the vast expenditure which the assumption of responsibility for Palestine and Iraq would involve. The view of British statesmanship was (as we read in Mr. Page's "Life and Letters") emphatically expressed by Lord Balfour as early as May, 1917. "My firm opinion is," he said, "that the Colonies ought not to be returned to the Germans. The natives, the Africans especially, have been so barbarously treated, and so immorally, that it would be inhuman to permit the Germans to rule and degrade them further. But Heaven forbid that we should still further enlarge the British Empire! Besides, we should incur the criticism of fighting in order to get more territory, and that was not, and is not, our aim. If (he added), the United States will help us, my wish is that these German Colonies should be internationalised,"—and the Turkish ex-colonies should be similarly treated.

Since Annexation was ruled out, equally with Restitution, there remained only Internationalisation. Anything in the nature of joint administration by a number of nations was admittedly wholly impracticable, and offered only prospects of friction, nor would it have been in the interests of the people concerned. Even a condominium of two nations only, had proved unworkable in Egypt. In Samoa it had led to partition in 1899, and in the New Hebrides it was a source of friction. Nor would such a scheme be acceptable to those Powers which demanded exclusive control over particular colonies. The alternative was the appointment of an individual Power, in whom would be vested responsibility

for the administration of each separate territory, as the Agent or Mandatory of the Powers.

For such a course there were precedents more or less analogous. The British and Dutch Royal Charters to Companies—and indeed the Orders issued to Colonial Governors—were written instruments conferring authority to govern as delegates. The Congress of Vienna, in 1859, had deputed Great Britain to control the Ionian Islands on behalf of the Powers. And nearer to our own time, King Leopold of Belgium had, in 1885, been appointed as the Mandatory of the Powers for the Administration of the "International Free State of the Congo," and Prince George of Greece had been similarly appointed to govern Crete in 1898. But the results were not entirely satisfactory, for there had been no clear definition of obligations, and no supervisory body. In the last two cases the Mandate had been issued to an individual and not to a State.

A closer analogy, as Professor Potter points out in the American *Political Science Review* is afforded by the proposal made by President Roosevelt in 1906, that France and Spain should hold a joint Mandate for Morocco, and that they should render to Italy, as the Supervising Authority on behalf of all the Powers, full and complete reports, and that she should have the right of inspection and verification, so as to ensure that all claims to equal commercial opportunity were duly observed. His proposal, however, was never carried into execution.

The creation of the League of Nations, however, afforded just such a supervisory body as was needed. It had neither the funds to meet the immense expenditure involved, nor the machinery to undertake the task itself, but it could provide the supervision over the Mandatories whom the Supreme Council of the Allies might appoint. It had nothing to do with the assignment of the Mandates, or their terms, or the extent or boundaries of the territory. It was not the author of the policy, but the instrument for its execution.

It was thus that the Mandate system became incorporated as a part of the Covenant of the League, and its objects and principles were defined in Article 22 of the Treaty. It had not quite the same international sanction as the Berlin and Brussels Acts, since the United States was not a party to the Treaty, and Germany signed it under duress as a consequence of defeat, but it acquired the sanction of the 50 Powers which constitute the League.

The Attitude of America.

The attitude of America towards the Mandate system is naturally of crucial importance, since she was the only one of the victors who did not sign the Treaty of Versailles, or become a member of the League. She objected to any form of annexation however rigidly conditioned, because she had doubts of the permanency of the League, and if it collapsed conditional annexation would come to be absolute. The policy as regards the inhabitants of these countries, which was laid down in Article 22 of the Covenant, was in accord with her own ideals—assistance and advice to the ex-Turkish colonies until they could govern themselves, trusteeship and tutelage for the backward races in the ex-German colonies. It was on the material side that American opinion was dissatisfied. Though not at war with Turkey, she made no exception as regards the Mandates which referred to ex-Turkish colonies, and claimed full participation for American oil-interests in Iraq. Her ambassador, writing to the Foreign Secretary in May, 1920, stated that "the future peace of the world requires as a general principle that any alien territory which should be acquired pursuant to the treaties of Peace with the Central Powers, must be held and governed in such a way as to secure free and equal treatment in law and in fact to the commerce of all nations." Secretary Colby, in November, 1920, reiterated even more strongly that this principle should govern all Mandate territories, and Secretary Hughes in February, 1921, declared that neither the Principal Powers, nor the League of Nations had the right to award or define a Mandate without the consent of the United States. He regarded the title of all Mandatories invalid without this consent.

Monopolistic exploitation of material resources is, as Prof. Charteris observes, excluded by the nature of the Mandate in the ex-Turkish colonies (Class A). In the B class (Central Africa), however, equal opportunity is assured only to members of the League, and it is not provided for at all in the C class (S.W. Africa and the Pacific). The restriction, or omission of this right of equal commercial opportunity

is regarded by the United States as inconsistent with the principles agreed on by the Allies at Paris, and in the Declaration accompanying the "Four-Power Treaty," America again took occasion to stipulate that "the treaty shall not be deemed to be an assent on the part of the United States to the Mandates."

On receipt of Mr. Hughes's note in February, 1921, the approval of the B Mandates for Central Africa was deferred, and the United States was invited to take part in the discussion on them, and on the A Mandates at the next session of Council. The C Mandates had already been approved by Council without reference to America. She did not accept the invitation, and the issue of the Mandates was delayed for a year and a half, while she entered into negotiations with the individual Mandatories. In the spring of 1922, agreement having been reached, the A and B Mandates were confirmed in July, 1922, and it was announced in the Press that formal treaties would follow.

The treaty with Japan (February, 1922), is the only one so far presented for registration. It reproduces the Mandate as confirmed by the Council of the League, and adds that the nationals of the United States shall enjoy the full benefit of all the rights and advantages accorded to the nationals of States Members of the League, and stipulates for equal opportunity, and that a duplicate of the Annual Report shall be sent to the United States. Any later modification of the Mandate, shall not affect the provisions of the treaty without its consent. A treaty was concluded also with Belgium in April, 1923, and received the approval of the Belgian Parliament last February. It has further been officially announced that a treaty was signed last April with France, relating to the French Mandate for Syria, which formally approves the Mandate and stipulates for equal opportunity. An annex to the treaty with Japan announces that the United States had not as yet entered into negotiations as to the Australian and New Zealand Mandates.

The United States has taken a steadily increasing share in the work of the League. She is officially represented on the Opium Commission, on the Committee dealing with the Traffic in Women and Children, on the Health Organisation, and on the Committee on Intellectual Co-operation. She has taken part in several technical Conferences and special problems, and is strongly represented on the League Secretariat. By her insistence in being consulted as to the terms of the Mandates, she inferentially shares responsibility for them. The original conception of the Mandate system has, as we have seen, been attributed to one American President, it owes its adoption to another; and it is to be hoped that before long she will be represented on the Mandates Commission, where her co-operation would be of the greatest value.

Distinctive Features of the System.

A Mandate territory, it has been pointed out, differs from a Protectorate in that a Protecting Power obtains rights over the population and against other Powers, whereas a Mandatory as guardian assumes obligations, both towards the League and towards the population, who thus acquire certain rights as against the Mandatory. The most distinctive feature of the system is the unqualified right of supervision vested in the League, which does not however, interfere with the absolute right of the Mandatory to make and enforce laws, to raise troops, to set up tribunals, to appoint officials, and to raise and spend revenues. It is *de facto* and *de jure*, the Government. Mandate territories do not come within the scope of existing treaties entered into by the Mandatory, nor will future treaties affect them unless it is so specifically stated.

The Allies apparently held the view that these territories passed to the victors by cession under the Treaties of Peace, and accordingly the Mandates for the ex-Turkish colonies were merely drafts until the treaty of Lausanne was signed. The United States, on the other hand, maintains, we are told, that they passed to the Allies and Associated Powers, not by Treaty, but as a result of the War, which did not extinguish her rights. It has indeed been maintained by the Judges of Appeal in the High Court of South Africa, that Germany did not cede her colonies to the Allies by the treaty of Versailles, but placed them at their disposal to be administered under Mandate—a status new to International Law.

The restrictions under the Mandates are not imposed upon a subject State, but are treaty obligations voluntarily undertaken—"self-imposed limitations of sovereignty," as Lord Balfour described them. It follows

that it is doubtful whether the League of Nations, which did not appoint the Mandatories, has any power to revoke a Mandate,* or whether a Mandatory can claim the right to resign its Mandate without denouncing the treaty in which it had its origin. There is no limit to the duration of a Mandate, and no penalty is prescribed for its breach. The only condition of termination contemplated is when the Mandate territory becomes a self-governing State, and is admitted as a Member of the League by a two-thirds majority. Revocation is apparently only possible if the International Court finds that the Mandatory has violated the terms of the Mandate, and transfer is only allowable with the mutual consent of the Council of the League and the Mandatory. "It is not in the power of the Council of the League, or of the Principal Powers to alter these Mandates," wrote M. Hymans in his report, which was adopted by the Council in 1920: "Amendments can only be made if the Covenant is revised." Lord Milner, Chairman of the Commission for dealing with the Mandates, made a similar statement in the House of Lords. These dicta must be understood to refer to alterations in substance, or to such as are incompatible with the terms of the Covenant, since amendment is provided for in the terms of the Mandate itself, with the concurrence of the Council and the Mandatory, and perhaps also with that of the United States. Such amendments have already been effected by the exclusion of Trans-Jordania from the clauses of the Palestine Mandate referring to the Jewish Home, and by the rectification of the Anglo-Belgian frontier in East Africa—which received the concurrence of the United States.

The Mandate System was thus a compromise between conflicting claims, pledges, and ideals, and in all the circumstances it was probably the best solution possible. It may be argued that Annexation, if limited and circumscribed by the self-same pledges as the existing Mandates, and subject to the same supervision of the League for their fulfilment, would have evaded some of the difficulties which, as we shall presently see, are inherent in the Mandate system, and would in other respects have made but little difference. That no doubt is true, but we have seen that Annexation—*eo nomine*—was wholly impossible.

* The Commonwealth Government, referring to the discussion on this subject, categorically stated on April 30th last, that it did not admit the power of the League of Nations to revoke a Mandate without the consent of the Mandatory.

DISTRIBUTION OF MANDATES.

The Power which had been principally concerned with the conquest of each Colony, or which had special interests in it by reason of its geographical position or otherwise, was selected as its Mandatory. Great Britain accepted the Mandates for Iraq and Palestine, France for Syria. Japan took the islands of the Pacific lately under German rule, north of the Equator, while Australia assumed responsibility for New Guinea and other islands south of the Equator, except for the Samoan group, which fell to New Zealand, and for the little island of Nauru, for which the British Empire as a whole became the Mandatory. South West Africa passed under the control of the Union of South Africa. In the case of Togoland in West Africa, two-thirds were assigned to France and one-third to Great Britain, and in the Cameroons about one-sixth was allotted to England and five-sixths to France. The kingdoms of Urundi and Ruanda in German East Africa fell to Belgium, the remainder, re-named "Tanganyika," to Great Britain; all the British Mandates are conferred upon the King on behalf of Great Britain or the several Dominions. Portugal obtained an adjustment in her favour of long-disputed boundaries in East Africa. There remained Armenia, decimated by Turkish massacres, whose people claimed that the Allies had made definite pledges to them. The Mandate was offered to the United States and refused. For lack of a Mandatory the country, together with Cilesia,—the Mandate for which had first been accepted but later abandoned by France—lapsed again to Turkey. Great Britain was already over-weighted with the responsibilities she had accepted. Whether these Mandates were offered to Italy, which had undertaken none, I do not know.

This omission gave rise to what I cannot but regard as a regrettable episode in these transactions, however urgent were the dictates of expediency. Great Britain and France agreed by the Pact of London of 1915 to compensate Italy by cession of territory if, as the result of these arrangements, they should enlarge their possessions in Africa. The British pledge is about to be redeemed by the cession of Jubaland. Man-

date territories are not "possessions," and it would seem, therefore, equitable that the territory thus added to Italy in compensation for the acquisition of Mandates by England and France, should be held under Mandate by Italy, but the promise was made in 1915 before the Mandates system was devised, and it is too late to alter its conditions now.

Though the exigencies of a war for existence may palliate exceptional measures, this arrangement was doubly unfortunate. In the first place it revived the immoral idea that territories in Africa could be exchanged as mere chattels or make-weights in a political bargain, and that pledges of protection and treaties with the natives could be set aside and transferred to another, without their knowledge and consent. "British subjects," said the Prince of Wales in reference to a rumoured transfer in the West Indies, "are not for sale." In the second place it gave colour to the assertions of cynics, who questioned the sincerity of the protestations of the Allies, and sneered at their professions of Trusteeship. It gave grounds for the criticism that the Mandates were but veiled annexation, by admitting the principle of compensation. Mr. Lloyd George also used this unfortunate phrase when he alleged that France would be "compensated" for the oil-wells of Iraq by her Mandate for Syria.

Mandates Altruistic.

The terms of Article 22 are explicit. Mandate territories are there described as a sacred trust, to be undertaken by nations who (*inter alia*) "by reason of their resources can best undertake this responsibility, and are willing to accept it." The inference that the burden was assumed from high and altruistic motives was explicitly affirmed later. When the Germans urged that the value of their Colonies should be a set-off against reparations, the Allies replied that "the Mandatory Powers, in so far as they may be appointed Trustees by the League of Nations, will derive no benefit from such Trusteeship." On these grounds they justified their refusal to refund to Germany, or to include as part of the reparation payments, the expenses she had incurred in the administration of these Colonies, or the value of the whole of the movable and immovable property. These pledges of disinterestedness thus became in effect part of the treaty in terms of which Germany renounced her Sovereignty in favour of the Allies. She, on her part, while not denying that a transfer of sovereignty involves the cession of all rights in State property, is understood to maintain that the loans raised by these Colonies for railways and public works were purely Colonial liabilities, for which the Imperial Government was in no way responsible.

Procedure Adopted.

The Mandates were conferred by the Supreme Council of the Allies, and after acceptance by each Mandatory were submitted to the Council of the League, which was charged with the duty of seeing that the terms were in accordance with the Covenant of the League embodied in the Treaty. There was some unfortunate delay in issuing the Mandates, detrimental to the welfare of the communities concerned, due in part to the difficulty of harmonising the claims of the Mandatories, in part to the necessity for consulting the United States as to their terms. In the meantime their legal position under the Hague Convention was that of countries in military occupation, in which no radical changes in the Civil Administration could be introduced.

It was not till July, 1922, nearly four years after the Armistice, that the Mandates dealing with the ex-German Colonies were issued. By that time it was six or seven years since the German Administration had been ousted in some of them. The delay in the issue of the ex-Turkish Mandates was even greater, owing in the first place to the long-deferred Treaty of Peace with Turkey, which was only concluded at Lausanne last August, and in the second place to a difficulty between France and Italy as to terms of the Syrian Mandate. Meanwhile Palestine and Syria were administered under draft Mandates. Iraq is supposed also to be administered under a draft Mandate, which, however, has never been published. A treaty has in the meantime been concluded between King Feisal and the Mandatory (Great Britain), dated October, 1922. A later protocol limited its duration to four years, or until Iraq becomes a member of the League, England supporting its application for membership. The treaty was subject to confirmation by the Constituent Assembly and the settlement of the Mosul question with Turkey. Thus in the case of Iraq, not only the burden of the Mandate, but the difficult task of settling the area over which it should extend was thrown upon the Man-

datory. In the last resort the matter will be referred to the League of Nations—a course to which Turkey has by treaty assented.

THE MANDATES COMMISSION.

The Powers which had accepted Mandates became Mandatories of the League, to which they undertook to submit an annual report. A Permanent Commission was set up by the League in accordance with Article 22, consisting of nine members appointed by the Council, the majority being nationals of Non-Mandatory States. They are selected "for personal merit and competence," as private individuals, and not as representatives of their respective nations. The nationality of the present members is Belgian, British, Dutch, French, Italian, Japanese, Portuguese, Spanish and Swedish, —the latter a lady. The Italian member is Chairman and the Dutch Vice-Chairman. There is a permanent Director (Swiss), an assistant Director (Italian), and a small staff, which receives petitions addressed to the Commission, collects the reports of public utterances in the Press of the world concerning Mandates and events in Mandated territories, and distributes to each member such as merit circulation. A member of the International Labour Organisation attends the Sessions, and takes part in all discussions relating to Labour, including slavery. His co-operation will, no doubt, ensure that "Labour" will be brought into closer touch and sympathy with these overseas territories.

The duties of the Mandates Commission are to see that the various territories are administered in conformity with the terms of the Mandates. For this purpose it meets at least once a year, and examines the report of the Mandatory in the presence of an accredited representative, who replies to questions put to him, or reserves his reply pending investigation. When each report has been reviewed, the Commission draws up its observations for submission to the Council, but each representative has the prior right of seeing the report of the Commission, and of recording a reply if he wishes to do so.

In order that the Mandatory may know the nature of the information desired by the Commission, a printed questionnaire has been sent to each, as a guide for the local Administrator in drawing up his annual report. It deals with the following subjects:—Slavery, labour, arms traffic, trade and manufacture of alcohol and drugs, liberty of conscience, military and defence forces, economic equality, education, public health, land tenure, the moral, social and material welfare of the natives, public finance, etc. It is, of course, the Mandatory, and not the local official, who is responsible to the League, and it is expected, that in forwarding the report of its local Administrator, the Mandatory will indicate whether it differs in any way from his conclusions, to what extent it intends to give effect to his recommendations, and generally to comment on, and identify itself with, the report.

Petitions from inhabitants of Mandate territories must be submitted through the Mandatory, which will forward them with its comments. Petitions regarding the inhabitants received from other sources are reviewed by the Chairman of the Commission, and if they appear to merit attention and are not obviously trivial, they are sent to the Mandatory concerned, for its comments. All petitions so dealt with are finally discussed by the Commission at its next session, and those which appear to call for action are submitted to the Council, with the Mandatory's and the Commission's comments.

CLASSES OF MANDATES.

The Covenant prescribes that the character of the Mandates must differ, in the varying circumstances of each territory, and it indicates three types of Mandate. *Class A* includes the ex-Turkish colonies—Iraq, Palestine and Syria, whose independence can, in the words of Article 22, "be provisionally recognised subject to the rendering of Administrative advice and assistance until they are able to stand alone." *Class B* comprises the Central African (ex-German) colonies—Togoland, Cameroons, Tanganyika and Ruanda. The Mandatory in this case is responsible for the Administration, and undertakes to promote the moral and material welfare of the people. *Class C* includes South West Africa and the Pacific islands, which are to be "administered by the Mandatory as an integral part of its own territory under its own laws, subject to the safeguards named in the interests of the natives."

These safeguards, which apply to the B and C classes are laid down in the Covenant. They are (1) Freedom of conscience and religion, subject only to the maintenance

of public order and morals; (2) Prohibition of abuses, such as the arms and liquor traffic, and the slave-trade; and (3) Prevention of fortifications, naval and military bases, and the training of natives except for police and defence. Equal commercial opportunity to States members of the League of Nations is guaranteed in Mandates of the B class only. Since some of the Mandates of the B class, *e.g.*, British Togoland and Cameroons, contain a clause identical with that which in the covenant appears to be peculiar to the C class—viz., that the Mandatory may administer the country as an integral part of its own territory—the only distinction remaining between the two classes is that the B class contains a stipulation for equal opportunity and the C class does not.

Nauru.

The Nauru Mandate presents some peculiar features which merit consideration. Nauru is a tiny island, only eight square miles in area, with 1,084 indigenous inhabitants, but it contains vast deposits of valuable phosphates. A concession to work these deposits was acquired from the Germans by a British company before the War. After the War, in consequence of rival claims by Australia and New Zealand, the British Government intervened, and an agreement, dated July, 1919, was arrived at. The three Governments bought out the British Phosphates Company in June, 1920, for a sum of 3½ million sterling, subscribed in proportions of 42, 42 and 16 (New Zealand), thus converting a privately-owned into a State monopoly. The working of the deposits was vested in a Phosphates Commission of nominees of the three Governments, and each was entitled to a share of the output for home consumption, in proportion to its subscription to the share capital. These transactions, it is important to note, took place prior to the issue of the Mandate.

The Mandate was conferred upon the King, on behalf of the Empire, and was included in the C class, which provides that a Mandatory shall administer under its own laws. But the British Empire has no single code of laws, and in terms of the 1919 agreement, responsibility for administration was assigned by the other two signatories to Australia, for a period of five years. All three Governments send representatives to Geneva to discuss the report on this tiny island with the Mandates Commission, and we learn that in all important matters the Commonwealth Government consults the other two. Prof. Charteris points out that though the joint responsibility of all three is thus fully acknowledged, there is an entire absence of Parliamentary control in any one of the three countries.

The United States took exception to the monopolistic exploitation of the phosphates, but this monopoly existed prior to the Mandate. Whether it was desirable that the Mandate should be conferred upon the States which owned the monopoly, and whether periodical transfer of administrative responsibility (if such is the intention), is in strict accord with the spirit of the Covenant are perhaps, open to question. The phosphates are worked by imported labour—Chinese and other—and the Mandates Commission is concerned with the conditions of these labourers, no less than with the equitable treatment of the indigenous natives.

Faults in the Terms of Mandates.

Since the Treaty of Versailles was signed the world has learnt from many sources how difficult was the task of the Representatives of the Allies to reach agreement in face of conflicting claims and prejudices, and the sensitive *amour propre* of the different Powers. It is not, therefore, to be wondered at that the high altruistic ideals to which the Covenant gave expression, were found difficult to translate into practice when the spoils of victory were to be divided. It is no small achievement in the circumstances that the signatories bound themselves to the general principle of Trusteeship. There were, however, some derelictions from the conditions laid down by Article 22.

Selection of Mandatory.

That article very clearly states that in territories placed under an A Mandate "the wishes of the communities must be a principal consideration in the selection of the Mandatory." The neglect of this proviso appears to be irreconcilable with the treaty. The paragraphs in Article 22 on which the B and C Mandates are framed do not contain any similar injunction, though explicit statements had been made in this sense.

Troops.

Again, it is difficult to reconcile the terms of the French Mandates in West Africa with

the terms of the Covenant. The latter expressly precludes "the military training of the natives for other than police purposes and the defence of the territory," while the Mandates for French Togo and Cameroons, unlike the British Mandates for the same places, add the words:—"It is understood, however, that the troops thus raised may, in the event of a general war, be utilised to repel an attack, or for defence of the territory outside that subject to the Mandate." The meaning is not very clear, but the Press has interpreted it as authorising the Mandatory to recruit troops in Mandate territory in case of a general war, and this precludes the possibility of neutralising these territories in time of war.

In this connexion it may be noted that the Mandates for both Palestine and Syria authorise the Mandatory to make use of the ports, railways, and roads for the movement of armed forces, and of all materials, supplies and fuel, and local forces may be used for purposes other than local defence. These countries would, therefore, as Dr. Lewis points out in the *Law Quarterly*, automatically become involved in any war in which the Mandatory may become engaged. Thus the restrictions on the use of troops recruited in Mandate territories for use elsewhere, which is imposed by the Covenant, and was one of the ostensible reasons for depriving Germany of them, does not apply to A Mandates, only partially to the B class, and it seems quite uncertain whether it applies to the C class or not. The Mandates Commission has recommended the Council that the enlistment of the inhabitants of a Mandate territory outside its borders should be considered as equally contrary to the spirit of the Mandate, and this suggestion has been submitted to the Mandatories for their opinions, and accepted by the British Government. It may be noted that by the terms of the French Mandate it is only troops "*thus* raised," *e.g.*, for purposes of local police and defence, which may be used outside the territory in time of war.

Equal Opportunity.

Apart from these apparent divergencies from the strict terms of the Treaty, the Covenant itself failed to fulfil all the expectations which the pre-Armistice declarations of the Allies had raised. We have already seen that the United States takes strong exception to the limitation of the pledge of equal commercial opportunity to the Central African Mandates, and there only to members of the League. American writers have denounced this action as selfish appropriation of material benefits, contrary to the spirit and implied obligations of the Treaty, and of a Trustee State, and opposed to the declaration of the Allies that they would derive no material benefits from the Mandates. Mr. Bullard, however, writing in an American journal, frankly admits that none of the overseas possessions of the United States which are of any international importance—such as the Philippines, Alaska, and Hawaii—maintain the "open door." "The only nation," he adds, "which has been more extreme in favouring its own trade in its Colonies is Japan." Japan herself, as another American writer points out, contended for the "open door" in C Mandates.

The British Finance Act, 1919, extends to Mandate territories the reduced scale of duties imposed on certain articles imported into the United Kingdom from other units of the Empire. It is, of course, entirely within the rights of any Power to impose, withdraw, or discriminate in regard to the duties it levies upon its imports, and no violation of the principle of equal opportunity is involved, provided that no reciprocity is demanded. It is conceivable that, in some cases, even a mutual preference might be to the economic advantage of the territory and its people, but it is obviously precluded by the terms of the Covenant as regards B Mandates.

Whether, in pursuance of the principle of equal opportunity, the Mandatory should purchase all materials for public works and other supplies in the cheapest market, and not necessarily in its own, and whether loans for the development of the territory should similarly be open to International subscription, are points which have so far not presented themselves for discussion. It is, however, clear that the altruistic ideal cannot with safety be carried too far, and unless the Mandatories, which have spent large sums upon the territories under their guardianship, are allowed to derive such advantage as close touch may afford, the Mandate system will become unpopular. It may be noted that the cost to the British taxpayer of the Mandates for Iraq and Palestine, as stated by the Under Secretary a year ago, showed an average of £38,128,342 per annum for the previous four years,

and that for Tanganyika (three years' average) was £681,333 per annum. The Cameroons cost about £30,000 per annum, which is paid by Nigerian funds.

It seems very regrettable that the principle of equal opportunity was not extended to C Mandates, and, in my personal opinion, it would have been wise, whether Germany joined the League or not, to throw open the door to German commercial enterprise in her former Colonies, where it is to be hoped that she would see a better system of administration under the Mandates than she had adopted in regard to the natives. To deny access to direct sources of supply of tropical raw materials and markets, vitally necessary to an industrial nation of sixty million souls, must necessarily engender bitterness and resentment, and add to the incentives for a new war.

Other Matters.

It may also be noted that the obligation to grant equal opportunity which is restricted to Members of the League applies also to missionaries, and this seems hardly compatible with the clause enforcing freedom of conscience and of religion.

A further subject of regret in the allotment of the Mandates arises from the fact that in some cases scanty regard has been paid to native interests, since the new political frontiers often intersect tribal areas. In East Africa a portion of the ancient kingdom of Ruanda had been assigned to England, in order to afford access for a possible future railway connecting Uganda with Tanganyika. Representations were made by the Mandates Commission, and Great Britain willingly ceded unconditionally the area in question to be included in the Belgian Mandate. Similar representations have been made in regard to tribal areas in the Cameroons, and are now under consideration.

Some difficulty has also been experienced from the looseness of the terms employed in the Covenant, as for instance, the term "Liquor Traffic." The interpretation given the other day in the House of Commons by the Colonial Secretary, viz., "The importation of cheap distilled liquors for sale or barter as an article of trade with the Natives," is undeniably the sense in which it has always been used in West Africa, but there are those who hold that the abolition of the Liquor Traffic means total prohibition. This would be in manifest divergence from the Treaty of St. Germain, concluded by the same Allies very shortly afterwards. (September 10, 1919.) Many other instances could be cited.

Inherent Difficulties.

With such defects in the Mandates the Mandates Commission has no direct concern, unless (as in the last quoted case), they form the subject of a complaint or petition. Since, however, the Mandate system constitutes a new departure in International Law and policy, it will be of interest to note some of the difficulties which have presented themselves, and the steps taken to consolidate the system.

The lack of any means of verification of the reports submitted—such as was contemplated in President Roosevelt's proposals—and of ascertaining whether they represent a true and impartial picture, without omission of any matters which ought to have been included by the Local Administrator—of which the Mandatory may itself, perhaps, be unaware—naturally militates against effective supervision. Outside critics are naturally reluctant to draw attention to such matters. In some cases they may fear that to do so may be prejudicial to their own material interests. The League is thus deprived of the only means at its disposal of enforcing the execution of the Mandate, viz., publicity and the force of public opinion, especially in the Mandatory country itself.

Lack of Permanence.

The term "Mandate" implies "un titre précaire," as M. Ryckmans calls it, and this unfounded fear of lack of permanence is a manifest obstacle both to the guaranteeing of loans by the Mandatory—by which better terms of flotation can be secured—and to the expenditure of capital in the country by the Mandatory or by private enterprise. If there were any uncertainty as to the continuance of the Mandate, the only security for investments by the Mandatory would be a lien on the railways or other public works for which the loan is required. But if the Mandatory owned the railways in its own right, it is argued that this would be tantamount to Annexation. This difficulty might perhaps be minimised if every loan was open to public subscription, not confined to the Mandatory nation, and if the security for any guaranteed loan consisted in a first charge on the revenues

of the territory,—a liability transferable with the Mandate itself, should such a contingency arise. The Syrian Mandate contains a clause designed to safeguard the financial obligations incurred during the continuance of the Mandate.

We have already seen that the Mandates have no time limit, and that for all practical purposes transfer is impossible and revocation unthinkable, but colour has been given to these suggestions of instability by proposals made in Parliament, and by responsible organs of the Press, that Great Britain should abandon the Mandates for Palestine and Iraq, on account of the heavy burden they have imposed on the British taxpayer, and it is within my own knowledge that would-be purchasers of the ex-enemy estates in Africa have been deterred by the same fear of insecurity of title. France, it is pointed out, resigned her Mandate for Cilesia; but her acceptance was only provisional, and no Mandate had been issued.

Voluntary resignation of an accepted Mandate—even if feasible without denouncing the Treaty under which the obligation was incurred—would be contrary to all British tradition, and no party in the State has been found to advocate the abandonment of a task to which this country has set its hand. The geographical and political reasons which prompted the acceptance of the Mandates she holds would still deter her from consenting to transfer them to other hands. But if, in spite of these considerations, private capital hesitates, and banks refuse to advance money on mortgages, the only satisfactory solution would seem to be that the Mandatory itself, being assured of the permanency of its retention of the Mandate, should give a guarantee against voluntary transfer or revocation. This would assure to private investment the same security that it would enjoy in a British Protectorate—and more cannot be reasonably demanded —and remove the economic disability under which a Mandate territory suffers.

A word regarding the ex-German estates, which for some years past have been advertised for sale, may be of interest. Under Article 260 of the Treaty, Germany was called upon to indemnify her nationals who were possessed of any rights and interests in her former colonies—their value being credited to Reparation account. Plantations formerly owned by German companies or individuals are not, therefore, the property of the Mandate Government, and whether sold, or retained and exploited by the State which holds the Mandate, their capital value and profits belong to the Reparation Fund. They are, however, like any other property, subject to taxes on behalf of the Revenues of the Mandate territory, and no preferential treatment in respect of labour supply or otherwise can be accorded to them, even though retained by the Mandatory State.

Status of Natives.

An initial difficulty was experienced in determining the status of the inhabitants of a Mandate territory of the B and C types. Since the territory was not annexed, it was universally agreed that they did not become nationals of the Mandatory Power. After much discussion the Council adopted the formula that "it is desirable that the native inhabitants should be designated by some form of descriptive title which will identify them as such," *e.g.*, as "persons administered or protected under Mandate." This does little to identify them with the Mandatory, and so deprives them of the incentive to loyalty and patriotism which counts for so much in the adjacent Colonies and Protectorates. It confers no juridical status, and no privilege of citizenship, but Article 327 stipulates that they shall be entitled to the diplomatic protection of the Mandatory outside the Mandate territory.

In pursuance of a suggestion by the Mandates Commission, the Council declared that it was not inconsistent with the conditions of a Mandate that the inhabitants of the territory should voluntarily obtain naturalisation from the Mandatory Power, in accordance with its own laws. The matter was brought forward by the Australian Government at the last Imperial Conference. British nationality cannot be acquired by residents in a Protectorate,—which is not British territory,—but the Conference approved that the power of granting certificates of Imperial naturalisation should be extended so as to cover persons resident in B and C Mandated territories, and also in certain named Protectorates. Similarly the Foreign Office lately agreed that the existing Extradition Treaties with France should be extended so as to apply to specified Protectorates, the inhabitants of which should for this purpose be "assimilated" to those of a Possession or Colony. England has been more unwilling

than any other nation to grant any status to a Protectorate, the need for which is shown by admissions such as these. I am not aware of the precise status of natives in a foreign Protectorate, but ours should not be inferior to them.

The question of Germans resident in S.W. Africa raises a separate problem, and the Union Government was authorised by the Council, apparently with some reluctance, to pass a general naturalisation law, without prejudice to the question whether the Mandatory system applies equally to non-natives as to natives. Any person may refuse naturalisation without any penalisation in practice. In the A class of Mandates, a local nationality as a stepping stone to self-government is, in theory at least, possible.

Participation in Conventions.

Mandate territories occupy, as we have seen, a status new to International Law, and, as the Mandates Commission has pointed out, International Conventions applicable to the adjacent Colonies and Protectorates of the Mandatory do not apply to them. They are, therefore, "liable to have their rights of free movement questioned, and also their rights to carry on trade and to own property outside the Mandate country. The benefits of the most-favoured-nation clause included in commercial treaties have been refused in the case of goods coming from a territory under a B Mandate, while products of the same kind coming from contiguous protectorates of the Mandatory State enjoy the benefit of this clause on being imported into the same country of destination." The Commission, therefore, recommended that all States Members of the League should accord to Mandate territories a status identical in this regard with the adjacent territories of the Mandatory, provided that the principle of economic equality in the B class is not infringed. The matter has been referred to the Mandatory Powers, and Great Britain will, I understand, reply in a not unfavourable sense. While pointing out that commercial treaties confer no personal privileges on the inhabitants and that such treaties do not apply to all Protectorates, she will, I understand, be willing to consider favourably any case submitted.

A Forward Step.

These instances will serve to illustrate some of the questions which arise in connexion with the Mandate system. It is, indeed, obvious that every effort to avoid the charge of Annexation, and to accentuate the distinction between the territories held under Mandate, and the adjacent territories under control of the Mandatory, must *pro tanto* accentuate the apparent instability of the system. It is as though one should endeavour to abolish the distinction between the holder of a lease in perpetuity and a freeholder. Since it is the general desire in this country that Germany and Turkey should join the League, it is well that such difficulties should be cleared out of the way before they do so. But though it is of interest to examine in some detail the working of a system new to International Law, initial mistakes, or temporary difficulties, must not be allowed to obscure the fundamental basis of the system. The principle thus accepted, and embodied in the Covenant and the Mandates, is that of Trusteeship, and of public responsibility to a supervisory authority for the execution of the obligations laid down in the Trust deed. It is the acceptance of this principle, whether it be formulated as a Mandate or as restricted appropriation, which constitutes the claim to progress.

The Annual Report forms an effective means of inviting a popular verdict on the fulfilment of the Trust. Neither the Mandates Commission, nor the Council, nor the Assembly can exercise any coercion, for the Mandatory, as Lord Balfour observed, is under the supervision and not under the control of the League. The ultimate authority to which the stewardship of the Mandatory is submitted is the public opinion of the civilised world.

Task of the Mandates Commission.

The Mandates Commission, which includes men with personal experience of administrative responsibility, who can realise local difficulties, and appreciate the futility of hypercritical comments, or interference with the discretion of the Mandatory, should in course of time become a valuable body, with a varied knowledge of Administrative problems in every part of the world. Its international composition ensures that its suggestions, made in consultation with the representative of the Mandatory, shall be devoid of any suspicion of bias. Its task is to promote co-operation,—which may extend beyond the frontiers of the Mandate

territory,—and to eliminate friction, while fearlessly exposing any manifest breach of the Mandate. The reports submitted have, generally speaking, been very full—indeed, in some cases, of embarrassing length; the specially accredited representatives have been men of eminence and knowledge; the discussions have been practical, and I think we are justified in believing that they have served, and will continue to serve, a useful purpose. Each Mandatory has been anxious to shew that it has not been backward in carrying out its pledges.

It is no mean achievement that the conquerors have (as Lord Balfour said), agreed to a self-imposed limitation of the sovereignty which they obtained over conquered territories, and consented to the supervision of the League. The high standards embodied in the Covenant must obviously in future be regarded as principles of general application. The responsibility is one which the advantages of an inherited civilisation, a superior intellectual culture, and twenty centuries of Christian ethics, no less than the physical superiority conferred by the monopoly of firearms, imposes upon the Powers in their dealings with the Backward Races. The Mandate system stands as an International acknowledgment that civilisation must be made to mean something higher to them than the aims and methods of the development syndicate, or the assiduous cultivation of new wants to afford markets for European commerce.

DISCUSSION.

Sir Horace A. Byatt, K.G.M.G., in opening the discussion, described how the Mandate system worked in the Tanganyika Territory, which it had been his privilege and honour to administer for the last seven years. Sir Frederick Lugard had referred to the unfortunate delay which had occurred in the issue of the Mandate; but from the point of view of local administration that delay, in some ways inconvenient, had been by no means regrettable, because it had given those in authority time to look round, to study local conditions, to come to know their people, to ascertain the people's real needs, and to formulate a policy on the lines which they supposed would be laid down by the Mandate. They had been able to anticipate to a very large degree the principles which had ultimately been laid down. There had been a little anxiety and uncertainty as to what the Mandate might impose, and as to what restrictions might be passed, but it had been a very great surprise and pleasure, when the Mandate at last appeared, to find that there was nothing in it which necessitated any change of policy. In the time which they had had at their disposal, they had already, if not actually enacted, at any rate progressed a long way towards the enactment of, such laws as the Mandate required them to promulgate; that was to say, they had dealt with the protection of natives from usury, with traffic in firearms, with the liquor traffic, and, either before or just after the issue of the Mandate, legislation had been promulgated which ensured security of tenure of land to the natives, not only for their present needs but for the needs of the future, taking into account their natural expansion. He desired to emphasise that when the Mandate was issued they had found that it embodied what he might call the unwritten Constitution of the British Colonies in Africa. It merely put down in black and white those abstract principles of justice and of trusteeship to the natives which had been adopted as a matter of course, and which were not in any sense forced upon them by the Mandate.

A good deal had been said about the burden which Great Britain had assumed in accepting responsibility for the government of these mandated territories. He wanted to show that that burden was not a great one, and that it was not likely to be a lasting one. There had been a good deal of adverse comment at various times in the Press—obviously made by people without sufficient knowledge. He had read, for instance, in the "Trade Supplement of *The Times*," and in other publications, various criticisms which were not at all justifiable. It had been said in one paper that Tanganyika was overrun with officials, and that Great Britain had twice the staff which the Germans had had; that the country was not half so well governed, and that, for that privilege, the British taxpayer was called upon to find a million sterling per annum. It was also said incidentally that the railway was the worst offender. As a matter of fact he had found, after searching carefully through the German records of 1913-14 that the number of European officials employed in German days had been 1,120, whereas the number employed by the British Government to-day was 860. On the two railways, the Central and the Northern, the British Government now employed 153 European officials, whereas on one railway only in the German days 149 had been employed; he had not been able to find the German figures for the second railway. He had noticed on another occasion that a certain speech which he had made had attracted a good deal of comment. In that speech he had referred to the necessity of improving the harbour facilities at Dar-es-Salaam, and also to the necessity of improving the railways. It had been said that if any improvement was required it was at Tanga, since the latter dealt with the bulk of the trade, and that it had behind it the great bulk of the native population. The plain facts were as follows. The value of the trade passing through Dar-es-Salaam was £1,370,000, and of that passing through Tanga only £608,000. The native population in the hinterland of Dar-es-Salaam was 1,482,000,

and in the hinterland of Tanga, 450,000. He merely quoted those figures to show that somewhat unfair comment had been made.

Tanganyika had undoubtedly been a burden on British taxpayers so far, but he thought it was impossible for anyone who had not resided in the country to realise the enormous damage and the complete destruction which had been effected by the War, and what a tremendous amount of reconstruction work was necessary, and the expenditure which that entailed. The burden was gradually decreasing. At no time had the British taxpayer been called upon to pay a million per annum. Sir F. Lugard had given the figure for last year, which was something over £600,000. In the present year it would be only £300,000. The trade of the country was increasing so rapidly, and the revenue improving to such an extent, that he looked forward to the time when Tanganyika would no longer be a burden on the British taxpayer, but would pay its own way. If one left aside the capital expenditure on reconstruction and the deficit on the railways, (a deficit that was rapidly diminishing), in the present year the difference between ordinary expenditure and normal revenue would be only some £30,000, and he had no doubt that next year that difference would be entirely eliminated.

With regard to trade, they had followed a policy entirely in accordance with the principles of the Mandate, namely, of encouraging native production. They had afforded the native opportunities, which he had never had in the German days, of becoming a small producer and of selling his crops in a good market. The result had been somewhat astonishing. In every commodity a very large increase had been shown over the German record figures. Twice as much coffee had been produced as in the German days, and with regard to ground nuts, whereas the Germans had produced 8,000 tons, last year 16,000 tons had been produced and this year 20,000 tons were expected and of grain two to three times the maximum amount exported by the Germans had been exported. The same could be said of most other commodities. He had no doubt whatever that in all commodities the German records of produce would be far surpassed.

He offered these remarks in order to show that the Tanganyika Territory as a mandated territory was not likely to be a burden on the British Empire. He had every confidence in stating that in the course of a very short time it would be a flourishing and a prosperous appanage of the Empire.

The Chairman (Lord Milner), said everyone must have listened with great satisfaction to the remarks of the last speaker. Speaking for himself as one who had had some experience of Colonial administration, he always found it particularly difficult to listen with patience to the complaints which were so often made in this country about the burden of our Colonial possessions. In the case of Tanganyika it really was ridiculous ever to have made a fuss about even the largest sum which we had been obliged to spend there if one considered the conditions of the country when it was taken over by Great Britain. Experience had shown us over and over again in scores of cases but we have never learned the lesson, that the liberal treatment of our Colonial territories, though it might involve for a few years a financial burden, rarely of considerable amount, invariably in the long run led to a development of the resources of those Colonies which directly relieved us of the burden and indirectly brought a very considerable accession of wealth to this country. There were a great many arguments other than financial for a liberal policy of Colonial development, but looked at from the purely financial point of view, in nine cases out of ten such a policy was in the long run not burdensome at all but very profitable. He was almost afraid to dwell on this point, although it was certainly the truth, because people turned round and said "Oh yes, finance is all you care about." It was not all he cared about as far as the Colonial Empire was concerned—very far from it; but he did think it was worth while to emphasise the point in order to get rid of an objection and a criticism which often did infinite harm by preventing a liberal administration of our Colonial possessions, especially in their early and struggling stages.

Turning now to the address, he had been particularly struck by the clear and absolutely correct analysis given by Sir F. Lugard of the conditions which had led after the conclusion of the War to what he might call the invention of the mandatory system, and of the influences which had brought it about. He would only add to what had been said that if the mandatory system had been called into existence mainly as a way out of the dilemma which Sir Frederick Lugard had described, it had been also partly the outcome of the idealistic spirit in which immediately after the War a great many people had approached the problem of world resettlement. Speaking for himself he had felt great sympathy with the mandatory idea, for he had hoped—when he came to look back upon it he saw that the hope was not altogether reasonable—that the spirit of cordial and unselfish co-operation which had been attained with difficulty but nevertheless ultimately attained, by the allied nations in the conduct of the War, would survive during the period of reconstruction, and especially that it might lead to a good settlement of the countries which the collapse of the German and Turkish Empires had left upon our hands and which it was the duty of the victorious nations to provide with some new form of government. It had, however, to be admitted that in the long-protracted negotiations which had resulted in the Mandates, such as they were, that spirit had been not only not always apparent but very often submerged by a return of the old rivalries and ambitions. If the hope to which he had referred had been fulfilled, and if the Mandates could have been brought into force with reasonable promptitude some great disasters would have been avoided, such as that which had befallen the Christian population of Armenia. More than that, the mandatory

system might have acquired a prestige which would have enabled it to be gradually extended to other portions of the world in which it seemed that the native populations were incapable without external aid of evolving any decent form of government. But fate had willed it otherwise. As things had actually turned out it seemed to him that the mandatory system, so far from obtaining greater extension, was likely as time went on to be contracted and to prove in many cases a mere transitory stage. Nevertheless, it remained even in its curtailed and more or less mutilated form—he meant as compared with the original big conception—a very important factor in the international situation. Therefore, it was well that we should take counsel as to the best use which could be made of it, and the best way in which the difficulties inherent in it might be met.

The lecture to which they had just listened was a very great contribution to the study of the subject. There were only two or three points of detail on which he would like to touch. With regard to C Mandates, he thought it was evident that the countries comprised in them had become or were becoming simply incorporated in the territories of the respective mandatory powers. No doubt the mandatory Powers held them under certain obligations. Those obligations were not at all onerous, certainly as far as the British Dominions were concerned, and also Japan probably. They imposed upon the mandatory Power no duty which it would not be obliged to discharge out of regard for its own principles and reputation as a civilised Power. He did not wish to underestimate the advantage which arose from the fact that those duties had now got an international sanction. No doubt it strengthened the hands of those people who in any of the mandatory countries were earnestly desirous of seeing that the power of their country should be exercised for the benefit of the backward races under its control.

With regard to B Mandates, the position was not equally simple. Sir F. Lugard had referred to two points especially with regard to which difficulties had arisen or might arise, namely, the question of recruitment of the natives of those mandated territories for military purposes, and the principle of equal opportunity for all States members of the League in respect of the commercial development of those countries.

It was certain that neither of those principles could be enforced with absolute rigidity. A certain freedom of interpretation was necessary. In the case of the recruitment of native levies, France had insisted on a fundamental modification of the Mandate for the Cameroons as originally drafted. With regard to the question of equal opportunity, personally he held that it was both right and necessary, having regard to all that had been said and what was laid down in the Mandates themselves, that mandated territory should be free to the commercial enterprise of all members of the League (he would go further and say of all nations). But it would be a mistake and would be fatal to the development of the mandated territory itself if the hands of the mandatory power were too rigidly tied about the financial arrangements which were essential for any honest effort to develop fully the resources of the country. It was a question of the reasonable interpretation of the Mandate—of looking to its spirit rather than to its actual letter—and personally he felt no doubt that if this question was ever raised the Mandates Commission would give a reasonable interpretation, and one in the interests of the mandated territory itself, to the principle of equal opportunity.

He observed that Sir F. Lugard had not said very much about the A Mandates. He was not surprised at that because it was not a cheerful subject of contemplation. Certainly it had been in everybody's mind when the mandatory system was first started, that it should be applied to Armenia and to certain other portions, never quite adequately defined, of the Turkish Empire in Asia. Those projects had long since passed in the limbo of bygone and forgotten dreams. It would have been very much better for the world and for the unfortunate Christian inhabitants of those countries if they could have been realised. With regard to Mesopotamia, frankly he did not know where we were. The one thing which was certain was that whatever might be the ultimate fate of Mesopotamia the Mandate for it would never materialise. That left, therefore, of the A Mandates only those for Syria and Palestine. He could not speak from personal knowledge about Syria, but Palestine did, in his opinion, present the best illustration possible of what could be accomplished under the mandatory system. He thought the difficulties besetting British administration in Palestine, though they were very real, had been somewhat exaggerated. There were two statements with regard to that country which could not be controverted. One was that in respect of order, justice, sound administration and material prosperity it had made a degree of progress in the past six years which would have been totally impossible without disinterested external aid. And the other was that, owing to the unique history and character of that country, to the fact that it was sacred soil for three great religious communities, and was of peculiar interest to the whole civilised world, it was a country to which the principle of the mandatory system, the principle of trusteeship, was peculiarly appropriate. One could never contemplate Palestine being the property of any single nation. One could not contemplate its being exclusively possessed by Moslem, Jew or Christian. They all had their rights on that sacred soil, and those rights could only be harmonised under the trusteeship of some impartial authority.

Hon. W. Ormsby-Gore, M.P., hoped Sir F. Lugard's paper would find its way into the Government offices both here and in the mandated territories, because one of the most remarkable things was that there was still extraordinary ignorance

both as to the obstacles and the difficulties on the one hand and as to the most elementary facts on the other. The main obstacle as he saw it was the lack of sense of security in the title of the Mandate. Practically all the troubles and difficulties had arisen from that fact. Sir Horace Byatt had said he thought the trouble was becoming easier from his point of view, but he could assure Sir Horace that the difficulty of getting a penny out of the Treasury for a mandated territory was enormous. It was difficult enough to get a penny out of the Treasury for the Colonies; it was still more difficult to do so for the Protectorates, and it was quite impossible to do so for mandated territories. That was true both of public and private enterprise. There was the greatest difficulty in disposing of ex-enemy properties in those territories. People enquired "What is this mandatory business?" They were suspicious of it. They had it at the back of their minds that such territories might possibly go back to Germany. Frankly, we had been faced with the difficulty, under the mandatory system, of attracting either public capital or private capital for the purposes of the development of those countries. He expressed the hope that the Permanent Mandates Commission would not merely content itself with being a critical body but would co-operate in a really constructive policy for the development of the mandated territories and would endeavour to bring in the whole public opinion of the world towards a solution of the problem which arose in those territories.

Lord Askwith, K.C.B., K.C., D.C.L. (Chairman of the Council), in proposing votes of thanks to Sir Frederick Lugard for his paper and to Lord Milner for presiding, said the paper was the clearest account of the question that he had ever heard, and stated a lot about Mandates of which most people did not know. Sir F. Lugard had been a man who for more than a generation had had great faith in the British Empire, a great belief in British commerce and a great trust in British administration.

He did not think that either Sir F. Lugard or Lord Milner had spoken with very great enthusiasm about the system of Mandates—a system which had arisen from some of those unfortunate phrases like "No annexations," "Self-determination" and so on.

What Lord Milner had said about the position of the mandatory countries was to his mind quite correct; but the time might come when, with the progress of the world, the people in those mandatory countries, one country after another, would ask for a change themselves. He confessed he would not care to be a citizen in a mandatory country and not to be able to say that he belonged to a great nation, but to have to say that he belonged to a country which was mandatory class A or mandatory class B., or mandatory class C. Some of those mandatory countries were going off already; others, some people said, we should give up; but others might remain for some considerable time. The difficulties with regard to administration and trade might lead to many changes in the future.

Sir Robert W. Hamilton, M.P., who would have taken part in the discussion if time had permitted, writes that the points which he intended to raise were the following:—

1. The status of mandated territories, and the manner in which that status should be made obvious to the world by the use of a flag.

2. The individual status of the inhabitants of a mandated territory, and how the suggestion of the grant of Imperial certificates of naturalisation could be carried out in practice, and if carried out, how far such grant would be consonant with the trustee idea.

3. The inevitable tendency for a mandated territory to be absorbed into the government of the Mandatory, and the conditions that would be likely to arise in the case of the federation of neighbouring colonies and mandated territories.

4. The extreme importance (with regard to Class B mandates in Africa) of the attempt to administer areas in tropical Africa in accordance with the spirit of the mandate, and free from any idea or suspicion of exploitation in the interests of the governing power, or of any class of individuals resident within the territory.

He desired (he adds) to raise these points rather with a view of eliciting information and stimulating discussion than to give any considered opinion on them himself.

THE RESOURCES OF PAPUA.

The following particulars regarding the resources of Papua have been collated by the Far Eastern Division of the United States Bureau of Foreign and Domestic Commerce, and published in the official "Commerce Reports":—

With a fertile soil capable of raising practically anything grown in the Tropics, with adequate rainfall, with deep and navigable rivers and excellent harbours, with valuable mineral deposits, with liberal land laws and easy-settlement terms, and with large sums of money already invested in plantations, shipping, and trade interests, Papua—one of Australia's richest dependencies—seems destined to become an important commercial market.

Lying north by north-east of Australia and separated from that country by Torres Strait, Papua (formerly known as British New Guinea) comprises the south-eastern part of the island of New Guinea, together with the outlying groups of islands—Trobriand, Woodlark, d'Entrecasteaux, the Louisiades, the Conflict group and the Laughlan group. The territory has 1,728 miles of sea-coast on the mainland and 1,936 miles of island coast. The total area of Papua is approximately 90,000 square miles. In 1922, the white population of the territory numbered about 1,104. Much of

the interior of the country has never been explored. The native population is estimated at from 250,000 to 350,000.

The products of Papua are obtained from its agriculture, its forests, its fisheries, and from mining and manufacturing.

The physical features of Papua are especially favourable to agriculture. The territory lies wholly within the Tropics. Its northernmost point is only 5° south of the Equator and its southernmost portion between 11° and 12° south. The country is remarkably well watered and it lies outside the hurricane belt of the south Pacific —a most important fact. Along the coast are immense areas of rich alluvial and volcanic soil, and even at an altitude of 6,000 feet the land is fertile.

In areas running back from the coast, where the soil is dry and rainfalls come at long intervals, conditions are said to be particularly suitable for the production of tobacco, fibres, etc. In 1920 the total agricultural area planted was 58,347 acres, averaging 237 acres to each plantation, the principal crops being coconuts, rubber, and sisal hemp. The natives are compelled by ordinance to plant coconuts for food supply. Secondary agricultural products of Papua include bowstring hemp, kapok, coffee, tobacco, vanilla beans, cacao, tapioca, cinnamon, tea, rice, and maize. Sugar cane also flourishes in the south-eastern part of the territory. Figures prepared in December, 1920, showed areas under cultivation as follows: Coconuts, 44,328 acres; rubber, 7,250 acres; hemp, 5,856 acres; miscellaneous crops, 900 acres. The quantity and value of products for the year ended June 30, 1921, were: Copra, 2,984 tons, worth £68,578; hemp, 188 tons, valued at £723; and rubber, 220 tons, worth £28,966.

The indigenous products of Papua include sandalwood and other timber, sugar cane, cotton plants, nutmegs, ginger, bamboos, palms, bananas, breadfruit, edible nuts, fruits, and vegetables. Forest products which have been catalogued show 120 varieties of timbers, 16 of which are adapted for use for girders, railway wagons, etc.; 10 for railway carriage and coach building; 15 for joinery, lining, floors, etc.; 15 for butter boxes; 5 for boat building; 4 for piles; and 15 for cabinetwork.

The highlands of Papua have immense possibilities for pastoral and dairying pursuits, the native grasses being particularly succulent.

Papua is rich in mineral deposits, which have been located over a very wide area. They include gold, copper, tin, lead, zinc, cinnabar, iron, osmiridium, gypsum, manganese, sulphur, graphite, chromite, brown coal, and petroleum. Large beds of apparently good coal are believed to exist. The total value of gold mined to June 30, 1921, was £1,567,168; while copper production during the period amounted in value to £114,795.

On account of the depth and force of the principal rivers of Papua the territory is exceptionally favourable for the introduction of hydro-electric schemes. The estimated water-power available for this purpose is equivalent to 10,000,000 horse-power.

TOBACCO INDUSTRY OF SOUTH AFRICA.

Tobacco-growing in South Africa has been steadily increasing during the past ten years. According to a report by the United States Consul at Cape Town, the area under cultivation at the present time is 26,000 acres and a variety of types are grown in the different Provinces. In the Transvaal a light and medium tobacco of the Virginia type is produced; in the south-central part of the Cape Province a medium to heavy type of Virginia is grown; and in Natal a medium dark tobacco is grown and used in the manufacture of cigars and a cheap grade of pipe tobacco. In the western part of the Cape Province Turkish Tobacco, such as Dubeck and Soulouk, is grown. The bulk of the tobacco produced is of the light to medium Virginia type. The Turkish leaf grown (amounting to 750,000 pounds) does not meet the demand.

The total production of all tobaccos grown in South Africa has been as follows: 11,644,000 pounds in 1920, 16,620,000 pounds in 1921, 13,000,000 in 1922. Frost and fire caused considerable damage to the 1923 crop. There are three co-operative tobacco societies in the Union of South Africa, the largest being the Rustenberg Farmers' Co-operative Society, which handles between 3,000,000 and 4,000,000 pounds of tobacco annually.

In 1920 there were 66 tobacco manufacturing plants in the Union, employing 2,662 persons. These plants have been using an increasing quantity of tobacco grown in South Africa and Rhodesia, and a decreasing amount of imported tobacco. For instance, in 1916, the raw tobacco consumed consisted of 8,000,000 pounds of South African and 466,020 lbs. of imported tobacco. In 1920 there was used 12,500,000 pounds of South African, 1,500,000 pounds of Rhodesian, and only 211,307 pounds of imported tobacco.

The full amount of tobacco which can be consumed within South Africa is now being produced, and if the output increases oversea markets must be found.

THE FRENCH OCHRE INDUSTRY.

The industry of extracting and preparing ochre is developed to a larger extent in France than in any other Euorpean country. The production is centred in two Departments—Yonne and Vaucluse—but while the production of Vaucluse is considerably smaller in quantity than that of Yonne, it is of superior quality both in colour and texture, and the output has a higher total money value.

From a report by the United States Vice-Consul at Marseilles, it appears that the title to ochre beds rests entirely in the landowner, who is generally a small farmer. No mining concession is needed for extraction, which is, in general, a seasonal occupation of the peasants.

An estimate from a reliable source places the ochre production of the Apt (Vaucluse) region at 20,000 metric tons for 1922, as compared with approximately 60,000 tons for the last year before

the war. The latest official figures (1920) showed about 11,000 tons produced.

The crude product is generally treated near the pit, and on the same property, but none of the product is consumed at the pits nor in the centres of production.

Ochre in barrels is bought and sold by a number of companies, some of which also exploit their own properties. There is no further preparation in France after the pulverised ochre is placed in barrels, marked and tested.

The product of Vaucluse finds a ready market in the United States and in Great Britain, the former taking about 50 per cent. and the latter about 35 per cent. of the total production. Exportation is through Marseilles. The product of the Department of Yonne goes largely to northern French ports.

It is said that by careful grading in foreign countries a mixture is made of ochre from the two French fields which gives excellent results. No such mixtures, however, are produced in France.

COPPER COINS IN CHINA.

The various mints in China during the past few years have turned out enormous quantities of copper coins. According to the United States Commercial Attaché at Peking, it is estimated that those now in circulation in the country number about 40,000,000,000. Copper is in reality the medium of exchange of the masses. With the fall in copper prices, and the wholesale minting of these coins in China, including the production in some cases of light-weight coins, the value of the copper cent has continued to fall, and has reached such a low level that many mints have discontinued its coinage as being no longer profitable. There is still, however, one other difficulty and that has to do with the issue of copper cent notes. These have been circulated on about the same basis as the value of the copper coins, and have shown little tendency to depreciate, except in cases of certain provincial issues other than those of the central Government.

This situation has had a serious effect upon the economic life of the people for the reason that the copper is the coin of the masses, and its depreciation affects their purchasing power very seriously. This is particularly true in the factories and modern industrial plants, where wages have been placed upon definite schedules. Among the farming population prices more easily adjust themselves, so as to cover any discrepancy regarding depreciation of currency.

CHINESE BANKS IN HONGKONG.

There are eight organised Chinese banking companies, with a paid-up capital of 25,000,000 Hongkong dollars and estimated deposits of 45,000,000 dollars, in Hongkong. According to the United States Consul at Hongkong, the number of these banks has doubled since 1918, and the volume of business done by them appears to be steadily increasing.

Modern Chinese banks in Hongkong employ methods similar to those used by the local foreign banks. They are registered and are governed by the ordinances of the Hongkong colony. They encourage foreign trade by the use of modern methods of financing, particularly through utilisation of the commercial letter of credit and acceptances. It is noteworthy that Chinese banks are increasing their connections in the United States, these being wider than those made with European countries. The European war was the most influential factor in effecting this result.

Besides the modern Chinese banks, there are about 25 native banks conducted in accordance with old Chinese customs, and these do a profitable and large business in Hongkong. Their operations are mostly confined to loans, mortgages, and the financing of shipments between ports and trade centres in China.

There are also about 300 money changers in Hongkong, with capitals varying from 5,000 to 50,000 Hongkong dollars. Their dealings are more directly with the masses, and a profitable return is secured on the business handled.

GENERAL NOTE.

Victoria and Albert Museum.—The Victoria and Albert Museum has recently purchased, with the assistance of a grant from the National Art-Collections Fund, a Writing Cabinet, signed "Samuel Bennett London Fecit". This is an important example of English furniture of the time of Queen Anne, made of walnut wood, with marquetry decoration of arabesque ornament in light wood. The upper part, closed by a door inset with a mirror, framed with fluted pilasters and panels of inlaid ornament, contains a cupboard and shelves, in which the architectural motive suggested in the decoration of the exterior is cleverly repeated. The lower part, with slope front and drawers, is fitted with a central cupboard flanked by drawers and pigeon-holes. The whole is surmounted by a pediment with carved scrolls and shield. This piece of furniture is of unusual importance from more than one point of view. It is a distinguished example of English furniture of the early part of the 18th century marked by high quality of workmanship. The fact that it bears the signature of the maker (inlaid on the inner surface of the door) makes it of particular value as a record, for it was not the usual practice for cabinet-makers in England to sign their furniture. Two other signed examples of the work of Samuel Bennett are known, one of which further shows that he lived in Monmouth Square, London. The fine proportions of the details and the restraint and good taste of the ornamental details give it special value as an example for students.

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FRIDAY, JULY 4, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.

NOTICE.

EXTRA MEETING.

WEDNESDAY, JULY 2nd, 1924; MR. ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, in the Chair.

A paper on "Results obtained over very long distances by Short-wave Directional Wireless Telegraphy, more generally referred to as the 'Beam System,'" was read by SENATOR GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., a Vice-President of the Society.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

ANNUAL GENERAL MEETING.

The One Hundred and Seventieth Annual General Meeting for the purpose of receiving the Report of the Council, and the Treasurers' Statement of Receipts and Payments during the past year, and also for the Election of Officers and New Fellows, was held in accordance with the By-Laws on Wednesday, June 25th, at 4 p.m. The RIGHT HON. LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the Chair.

THE SECRETARY read the notice convening the meeting, and the Minutes of the last Annual General Meeting held on June 27th, 1923.

The following candidates were proposed, balloted for, and duly elected Fellows of the Society:—

Allen, John Scott, Lismore, Ireland.
Blake, Captain Sir H. Acton, K.C.M.G., K.C.V.O., London.
Cawston, Frederick Gordon, M.D., B.Ch., M.R.C.S., L.R.C.P., Durban, South Africa.
Coriell, Louis Duncan, Baltimore, U.S.A.
Cowasjee, Bomanjee, London.
Dalrymple, Col. Sir William, K.B.E., London.
Daniell, Major John Alan Le Norreys, Sudbury, Suffolk.
Dixon, Edward, London.
Durran, William, London.
Freudenthal, Louis Edwin, B.S., Las Cruces, New Mexico, U.S.A.
Frost, Captain Frederick James Tabor, Ramon F. Castro, Argentine.
Gurtu, Raj K., Cawnpore, India.
Ibbotson, Herbert J., Johannesburg, South Africa.
Jenkins, Arnold, Worthing.
Longman, Charles James, M.A., J.P., London.
Mattocks, Captain F. S., R.E., Quetta, Baluchistan, India.
Oxley, Oswald John Philip, Durban, South Africa.
Raju, M.G., L.M.E., Guntur, Madras, India.
Rodmayne, Sir Richard Augustine Studdert, K.C.B., M. Inst. C.E., London.
Redwood, Robert, London.
Rummel, G. Albert, Cincinnati, U.S.A.
Shepherd, William Thomas, M.A., M.Sc., Ph.D., Washington, D.C., U.S.A.
Wright, Robert William, London.
Young, Walter J., C.B.E., Adelaide, Australia.
Zaharoff, Sir Basil, G.C.B., G.B.E., D.C.L., Paris.

THE CHAIRMAN appointed MR. CHARLES J. INNES-BAILLIE and MR. ROBERT J. MONEY scrutineers and declared the ballot open.

THE SECRETARY then read the following

REPORT OF COUNCIL

1.—ORDINARY MEETINGS.

For his inaugural address Lord Askwith selected the subject of "Exhibitions"—a subject on which he was specially qualified to speak by former experience as Head of the Exhibitions Department of the Board of Trade. There can be no doubt that the idea of Industrial as well as Fine Art Exhibitions originated with the Society, for from 1761 onwards they organised numerous exhibitions, culminating in the Great Exhibition of 1851. After giving a history of International Exhibitions from that date up to the present time, Lord Askwith discussed the main principles on which exhibitions should be conducted, and concluded by outlining the principal results which might be hoped for from the British Empire Exhibition, 1924.

M. Edouard Belin, the distinguished French electrical engineer, read a paper, illustrated by numerous experiments,

on "Téléphotographie, Télautographie, Télévision." In 1907 he succeeded, by means of appliances based on the use of selenium, in transmitting by telegraph a picture from Paris to Bordeaux. The result, however, was not quite satisfactory, as the outlines were considerably blurred; and he then adopted a new process, based on the use of gelatine bichromate. Details of the apparatus and method were explained and a satisfactory picture was transmitted across the lecture room. Specimens of "télautographie" were also shown, demonstrating the possibility of sending messages in a person's own handwriting, or in shorthand, or in such character as Arabic or Chinese. With regard to télévision, M. Belin stated that certain results had been obtained by means of appliances based on selenium. A great deal more work will, however, have to be done before télévision can be regarded as beyond the experimental stage.

In his paper, "Forgeries of Ancient Stained Glass," Mr. J. A. Knowles described various methods by which such forgeries may be produced and detected. As the habit of paying large prices for old glass is of comparatively recent years, the practice of making forgeries for profit would appear to be a modern growth. The person who suspects a forgery should devote his attention to the materials and the technique. The constitution of glass and of enamels has, of course, varied greatly from time to time, and so have the methods of the artists: if, therefore, one finds a piece of work in the style of the eighteenth century on a piece of glass of the fourteenth century, it may quite possibly turn out that the whole was made in Germany in the late nineteenth century. Mr. Knowles discussed the subject in considerable detail, and brought together a quantity of fresh material which will be of great interest and value to the connoisseur of stained glass.

Sir Henry Gauvain read a paper on "The Effect of Sun, Sea and Open-air in the Treatment of Diseases," in which he described the work conducted at the Lord Mayor Treloar Cripples' Hospital at Alton and Hayling Island. Although the value of the sun as a healing agency has been recognised instinctively from early times, it is only within the present century that its effects have been the subject of careful scientific study. The work was begun independently by Rollier in Leysin and Sir Henry Gauvain himself. Quite astonishing cures have already been effected, and it seems probable that further research will before long open an entirely new chapter in therapeutics. It has already been found that exposure to various kinds of light enormously increases the bactericidal powers of the blood. Further investigations are being made in this direction, and if the results so far observed are confirmed, a new weapon will be placed in the hands of the physician, the power of which in the treatment of disease bids fair to be of epoch-making importance.

Dr. Arthur William Hill, in his paper "The Work of the Royal Botanic Gardens, Kew," gave a brief history of the famous gardens, and some account of the work of its chief directors, such as Sir William and Sir Joseph Hooker, Sir Joseph Banks, Sir William Thistleton-Dyer and Sir David Prain. This was followed by a description of the work now carried on at Kew, which is of an astonishingly varied nature. Botanists trained at Kew have gone out to all parts of the world and made known the resources of the Gardens, and the result is that at Kew advice is sought not only from every part of the British Empire, but from every country where an interest is taken in botany, whether theoretical or practical. Enormous help has been rendered in this way to industry and commerce. To quote two instances, the Para rubber industry of the East, and the cultivation of cinchona in India, Ceylon and Jamaica both owed their origin and success to Kew.

Among the many and various duties of H.M. Office of Works, not the least important is the preservation of ancient monuments and historic buildings. A paper on this subject was read by Sir Frank Baines, in which he defined the principles followed by H.M. Office of Works in this branch of their work. He drew a careful distinction between "preservation" and "restoration," and held that it was the duty of his department to preserve, not to restore, the monuments and buildings handed over to their charge. A vast amount of preservative work has been carried out in recent years by H.M. Office of Works. Sir Frank Baines described a great deal of this with the aid of a very beautiful series of slides, especially notable among which were the roofs at Westminster Hall, and Hampton Court Palace, and the exceedingly successful treatment of Dryburgh Abbey.

In 1908 Mr. G. Albert Smith read a paper on "Animated Photographs in Natural Colours," when he described the process which subsequently became well known under the name "kinemacolor." In that process three lenses were at first employed (and subsequently two); but although these were placed as close together as possible, they necessarily took three pictures which differed very slightly from each other. When these were superimposed there was a resultant "fringing" of colour. Since then considerable developments have taken place, and it is now possible by the invention of a new lens to take two identical snapshots at once. A description of the lens was given by Mr. Albert Smith. The process is known as "Cinechrome." It was employed for the purpose of taking films of H.R.H. the Prince of Wales's tour in India and Burma, and the results as shown at the meeting were generally considered to be extremely striking and successful.

"The Earthquake and the Work of Reconstruction in Japan" was the title of a paper read by Mr. Iyemasa Tokuwaga. Although he had not himself been an eye-witness of the calamity, Mr. Tokuwaga was enabled from official reports, letters from friends in Japan and other sources, to present a vivid account of the havoc wrought by the earthquake and the subsequent conflagration and tidal waves. He also exhibited a series of cinematographic films; the first of these showed Tokio before the earthquake, the others gave impressive pictures of the enormous fires which raged for many days, and of the utter devastation left behind by perhaps the most appalling natural catastrophe of which we have any record.

Public attention has frequently been drawn in recent years to the destruction wrought by the death-watch beetle in the timber roofs of some of our finest and most beautiful buildings. Westminster Hall and Hampton Court are two of the best known instances that have suffered from this cause, but there are cases all over the country where buildings of extraordinary interest are perishing from day to day. Professor H. Maxwell-Lefroy, who has devoted much time to studying the life-history of the beetle and the best methods of attacking it, pleaded for a systematic standardisation of our knowledge on the subject, and for a careful research as to the treatment to be adopted. It is a curious fact that in a good many cases where roofs have been attacked by the beetle, after some time the attack seems to have ceased automatically. If one could discover the conditions which have led to this state of things, one might be able to find out further how these conditions might be produced.

A few years ago there were imported into this country between 40,000 and 50,000 tons of rubber in excess of our normal requirements, and those interested in the industry have been anxious to find new uses for this excess production. A paper on the subject was read by Mr. P. J. Burgess. By the direct use of latex, which has come into vogue during the last five years, it has become possible to employ rubber in the manufacture of waterproof papers, mill-boards, artificial leather, etc., and the growing popularity of crepe rubber for shoe and boot soles has accounted for a certain amount of the excess production; but all these together will not do a great deal to remedy the troubles of the rubber growers, who are looking for new uses, or great extension of old uses, for this material, and Mr. Burgess thinks that their best hope lies in the extended employment of rubber for road surfaces.

Every year about half-a-million children are thrown out of our elementary schools on to the labour market, and they have to sort themselves as best they can to the posts that are available. Naturally this is a very difficult matter, and frequently square pegs try to settle into many round holes before they find a resting place into which they can fit their angular proportions. The National Institute of Psychology has for some time been busy devising and practising tests which may assist in determining the occupations for which persons are most suited. Dr. Charles S. Myers, the Director of the Institute, in his paper, gave an account of some of these tests, which have been applied with considerable success. It is interesting to note that a good deal of work on these lines has been conducted in the United States, Spain, Belgium, Switzerland, Germany, Japan and elsewhere. In Berlin the movement is supported financially by the Trades Unions, who believe that the tests will assist them in keeping "duds" out of the Unions.

Although a communication on the subject of quartz fusion was submitted to the Paris Academy of Science in 1839, it is only within very recent years that the

utilisation of this material has been placed on a commercial basis. Sir Richard Paget, in his paper "The History, Development and Commercial Uses of Fused Silica," gave an interesting historical account of the early work done by various experimentalists, including Sir Charles Parsons and Professor C. Vernon Boys, and of the present state of the industry. Fused silica has several important properties which render it extraordinarily useful in operations conducted at very high temperatures. Its co-efficient of expansion is extremely low, its softening point is very high, it is as hard as hard glass, and its crushing strength is very great. With these qualities there is obviously a wide field for the utilisation of fused silica; but Sir Richard Paget's audience seemed to be greatly astonished by the variety and size of the appliances which he was able to exhibit at the meeting, especially by a large flask-shaped vessel with a capacity of 170 gallons.

Over a million subjects of the British Empire fell during the Great War. Their graves form a girdle of honour round the world. The cemeteries in which they lie are stretched through France, Belgium, Switzerland, Italy, Macedonia, Gallipoli, Syria, Palestine, Egypt, Mesopotamia, East Africa, China, Australia, New Zealand, Canada and back to the United Kingdom. The care of these has been undertaken by the Imperial War Graves Commission, whose Vice-Chairman, Sir Fabian Ware, described in an eloquent paper the steps which are being taken to render them worthy resting places of our immortal dead. Some of our best known engineers and architects have devoted themselves to the task of making these burying grounds permanent and artistic, whilst an army of gardeners is still at work adding to the honoured graves the beauty of lawns and appropriate flowers. Boundless care has been spent not only on the general features of the cemeteries, but in the smallest details of the inscriptions on the graves; and it must be some consolation to those who are left to mourn that the names of their dead are preserved in so much honour by the country which they died to defend.

The vital importance of timbers to many branches of industry was brought home to most of us during the War; but those whose duty it was to consider questions of forestry had long before this been growing anxious as to possible sources of supply for our ever-increasing requirements. Countries which used to export timber to us in large quantities are beginning to find that they have no more than enough for their own needs; and when one hears of single mills in the United States that consume daily sixty acres of timber one begins to realise that the prospect of a world shortage is no mere nightmare fantasy of the forester. It is, therefore, of extreme importance that we should take stock of the resources at our disposal, and this was done, so far as North America is concerned, by Mr. R. L. Robinson. In view of the fact that the United States are rapidly coming to require for their own use all the timber that they can grow, Mr. Robinson urged (1) that we ought to pay more attention to the forests in our own tropical colonies, where we can find good substitutes for hard woods at present obtained from America, and (2) that in this country we should go forward with our forest policy, in full confidence that it will prove a sound national investment.

In his paper on "The Fishing Industry and its By-Products," Mr. Neal Green urged the further application of science in studying various kinds of fish and in developing the sources of their supply. Comparatively little has been done in this direction, and in view of the difficulties of securing control where so vast and turbulent a factor as the sea is involved, it seems rash to hope at present for great developments on these lines. Certain experiments dealing with the transference of young fish to the Dogger Bank, where they developed rapidly in weight and quality, have, however, proved encouraging, and Mr. Neal Green seemed disposed to hope for further success on these and similar lines. He also foresaw a time when improved methods of refrigeration would bring the fish of the South Seas within the reach of European markets. In connexion with fishery by-products the application of science has already been well proved. Fish meal is being produced in ever-increasing quantities and being used with ever-increasing success in the feeding of farm-stock, chickens, etc., whilst excellent glues, isinglass and other materials are being recovered from the waste of the fish.

A special interest was lent to Sir Lynden Macassey's paper on "London Traffic" by the strike of omnibus and tramway men,

which was only settled on the eve of the meeting at which the paper was read. Sir Lynden pointed out that it was the Great Exhibition of 1851 which forced on public attention the deplorable conditions then existing in regard to the streets of the Metropolis, and an agitation was started which finally led to the appointment of the Metropolitan Board of Works. Many of the road improvements of the last century could be traced back to the 1851 Exhibition, and the author asked whether the British Empire Exhibition of this year would give a similar impulse to public opinion. The Royal Commission on London Traffic, of which Sir Lynden was Secretary from 1903-7, made an exhaustive enquiry into the whole subject and presented an illuminating report. In his paper the author emphasised the inherent difficulties of the situation, examined the broad principles underlying the remedies proposed by the Commission, and finally examined the London Traffic Bill, now before Parliament, with a view to ascertaining how far it harmonises with the recommendations of the Commission.

While communication with the London Docks by water and railways is good, the roads connecting them with the Metropolis are deplorable. Particularly is this the case with the Victoria Dock district, and with the latter-day increase of motor traffic the drawbacks have become more and more apparent, until there is now a crying need for reform. With the totally inadequate accommodation provided by the existing roads, traffic is held up, and workmen proceeding to the docks are so delayed by the swing-bridges that they often lose a whole day's work. Sir Henry Maybury, in his paper, "The Victoria Dock District and its Roads," pleaded for a scheme of wide new roads capable of bearing the traffic of to-day without congestion. The cost of his proposals he placed at £2,000,000 to £3,000,000, and as it is not likely that this could be borne by the local rates of a poor district, he urged that the scheme should be regarded as an all-London task. Seeing that the London docks are in reality the gateway to the Empire, there seems to be ample justification for his proposal.

Mr. F. Hope-Jones, in a paper entitled "The Free Pendulum," described his very beautiful invention by which it is possible to measure time with a precision never before obtained. The apparatus is extremely delicate and complicated, and it is impossible to explain the mechanism in a few sentences, but the general idea is this: by means of a "slave clock" the pendulum of the "master clock" is freed from all interference, that is to say, it has nothing to do but to swing. The impulse is uniform; it is delivered at or about zero; it is extremely small in quantity, and is imparted at regular intervals of thirty seconds. The pendulum swings in a vacuum, which eliminates all barometric considerations, and the clock is erected in a room kept at a constant temperature.

Any invention which assists navigators either of ships or aircraft to ascertain their exact position must obviously be of great importance as tending to secure the safety of life and property. In foggy weather it is often impossible for days on end to make reliable observations. In these circumstances the use of wireless must be an enormous relief to the navigator. Dr. J. Robinson, in his paper, "Wireless Navigation for Ships and Aircraft," described various systems (including his own) whereby signals are transmitted from direction-finding stations. It would appear that far greater advantage is taken of these aids to navigation in America than in this country. In the approaches to New York Harbour alone there are far more stations than in the whole of England.

In his paper, "Furs and the Fur Trade," Mr. F. C. Ingrams gave a résumé of the history of the fur trade, which is obviously one of the oldest trades in the world. An interesting feature of the paper was the list of names of furs, now obsolete, which were in use in the Middle Ages, such as lettice, miniver, lucerne, pampilion, strandling, etc., all of which the author had identified with the greatest care. Towards the close of the paper Mr. Ingrams gave a number of statistics from which one can form a very good idea of the size and importance of the trade at the present day. At the last London fur auctions there were offered over four-and-a-half million musquash pelts, nearly two-and-a-quarter million skunk, over a million squirrel, a million opossum, and over half-a-million Persian lamb. Mention was made of the growing industry of fox farming; in 1922 there were 977 fox farms in Canada, with a total of 24,163 foxes.

Sir William Pope, who delivered the seventh Trueman Wood Lecture, selected as his subject "The Outlook in Chemistry."

The first part was devoted to summarising the principal developments which have taken place during the last twenty-five years in physical science, and the profound effects which they have produced in modifying our theories of chemistry. These changes would appear to call for corresponding modifications in our educational methods, which are still too apt to cling to the water-tight compartments into which science has been divided for so long. The conclusion of the lecture contained an earnest plea for collective effort in the application of science to industry. In the coal tar industry, the gas industry, and various great manufactures, proof has already been given of the great results that may be achieved by "team work"; and Sir William urged the need for large and comprehensive plans involving much experimental work in order to provide the vast amount of precise data essential to the application of chemistry to technical ends.

"The Position of the Arabs in Art and Literature" was the title of a paper by Mrs. Arthur McGrath (Rosita Forbes). As one who has travelled extensively in known and unknown parts of Asia and Africa Mrs. McGrath has a wide and profound knowledge of the Arabs and their arts. These are very varied, and include architecture, wood carving, ceramics, miniatures, ivories, carpets, stuffs, arms, bronzes, gold and silver work, enamelled glass and illuminated manuscripts. Mrs. McGrath gave an admirable summary of the principal characteristics of Arab art, and she then passed on to discuss Arab literature, which she described as one of the richest in the world.

II.—Extra Meetings.

In addition to the Ordinary Meetings, three extra meetings were arranged during the session. At the first of these, which had to be held before the opening of the session, Dr. C. E. K. Mees described the Kodascope, an instrument devised by the Kodak Company to enable amateurs to take cinematograph films. The apparatus is on a considerably smaller scale than that used by professional cinematographers, and is comparatively inexpensive. Several films were taken at the beginning of the meeting and exhibited in the hall an hour later. The results were admirable; and Dr. Mees expressed his belief that, with the help of this instrument, cinematography would be enabled to benefit in the future by the work of the amateur, just as its sister art, photography, had benefited in the past.

Mr. G. M. Booth, in his paper, "The Amazon Valley and its Development," gave an interesting account of the greatest of all rivers, its fauna, flora, and the possibilities of development in its basin, which is as large as the whole of Europe. The interest of this paper was greatly increased by a fine collection of specimens illustrating the resources of the Amazon, which was on view in the library from April 4-18th, and was visited by a large number of persons.

Mr. T. Thorne Baker, who had previously given two excellent papers before the Society, read a third entitled "Photography in Science, Industry and Medicine." His demonstration of the extent to which photography is used as an aid to science will probably come as a revelation to most people. The spectroscopic camera, or spectrograph, is invaluable as a means of rapid chemical analysis, especially as it indicates exceedingly minute quantities. One of the most recent inventions is a photo-micrographic apparatus by which magnifications of 25,000 diameters can be obtained. The use of X-rays in medicine and surgery, and also in such cases as detecting flaws in metals and other materials is growing day by day, and with the rapid advances in the technique of photography, they can be so employed with ever-increasing advantages. Mr. Thorne Baker, in his comprehensive review, gave an illuminating account of the many directions in which photography is now being applied to scientific purposes: perhaps one of his most striking instances was a cardiograph recorded in a consulting room half-a-mile from where the patient lay.

III.—Indian and Dominions and Colonies Sections.

The two sections of the Society each provided seven excellent meetings and, owing to additional dates in the present session not being available, some further offers of papers had to be deferred or put aside. As it was, the number in both sections was larger than usual, while the standard has probably never been higher.

The papers contributed to the Indian Section were, in chronological order, as follows:— (1) "The Indian Ordnance Factories and Indian Industries," by Brigadier-General H. A. Young; (2) "The

Survey of India," by Colonel H. L. Crosthwait; (3) "Salt Manufacture in India," by Sir Richard M. Dane; (4) "The Progress of Co-operative Banking in India," by Mr. Otto Rothfeld; (5) "Chemical Research in India," by Prof. Jocelyn F. Thorpe; and (6) "The Art of the Pāl Empire in Bengal," by Mr. J. C. French. The annual Sir George Birdwood Memorial Lecture, founded in 1919 by the friends of that remarkable man to record his long and devoted services to the Society, especially the Indian Section, was delivered by Mr. William Foster, Historiographer to the India Office, his subject being "The Archives of the Honourable East India Company."

The following were the papers read in the Dominions and Colonies Section:—(1) "The West Indies," by Viscount Burnham; (2) "Empire Settlement," by the Agent-General for Ontario, Mr. W. C. Noxon; (3) "The Commercial Future of the Backward Races," by Mr. F. W. Walker; (4) "Empire Oil: Progress of Sarawak," by the Hon. T. G. Cochrane; (5) "The Geology and Mineral Resources of Cyprus," by Prof. C. Gilbert Cullis; (6) "The Mandate System and the British Mandates," by Sir Frederick Lugard; and (7) "The Mineral Wealth of the pre-Cambrian in Canada," by Dr. C. V. Corless.

The paper of General Young, though mainly historical, dealt also with some problems of great immediate importance, such as the development of Indian industries, now occupying so much attention, a task for which his long and varied experience eminently fitted him. For close upon thirty years he was connected with the ordnance factories of India, and first as Deputy Director of the Department and then as Director had much to do with the valuable military assistance which that country was able to give the Empire in the Great War. It is moreover to the credit of General Young and his predecessors that the general record of the ordnance factories of India is scarcely less renowned in peace than in war, for they can claim to have been the pioneers of modern industrial developments in that country, and must, in General Young's opinion, be used in the same way to the fullest extent to secure progress on sound lines. He does not think that complete "Indianisation" is possible in the near future, or, indeed, that it will be achieved "till a generation of educated Indians arises, trained in mechanical and engineering sciences, experienced in subordinate management and having the power of studying and of assimilating the industrial progress of other countries."

Many Fellows of the Society will remember the paper a valued ex-Chairman of the Council, Sir Thomas H. Holdich, read eight years ago, "Romance of the Survey of India." Colonel Crosthwait began his paper by modestly expressing inability to "emulate the charming and picturesque language with which his former chief habitually adorns his addresses." His own purpose, he explained, was to give the Society an idea of how the geographical survey of a vast country is carried out; how its maps are made; the nature of the scientific work undertaken by the Survey of India, in short, to describe in outline the many enterprises with which that great organisation is concerned. He conveniently divided the work of the Department under three heads:—1. Geodesy; 2. Topography and the drawing of the "fair map"; 3. The reproduction and printing of the map. Regarding the future of scientific operations in India, he thinks that even in these days of financial stringency there will probably not be much difficulty in getting funds for map-making. "Let us hope," he said in conclusion, "that no effort will be spared to continue the world-renowned scientific work of the Survey of India, the foundations of which have been so firmly laid by Everest, Walker and Burrard."

In a comprehensive paper on "The Manufacture of Salt in India," Sir Richard M. Dane took, as the text of his survey, a remark appearing in a pamphlet published in 1884 for the International Health Exhibition and the Royal Society of Arts, that "the salt produced in India whether from washing salt-soil or from the mines in the Salt Range in the Punjab or from the evaporation of sea-water on the coast was, and is, still of an inferior character, more or less dirty in colour and containing from 10 to 12 per cent. of impurities." The statement, so far as Punjab rock-salt is concerned, is, Sir R. Dane said, incorrect. Much of the salt made in Rajputana also is of very good quality and in some places in Sind perfectly pure naturally-formed salt can be collected. It is, however, the case that, except in the north-west, India is not well provided with good salt, and the salt made from sea water by solar heat on the coasts of Bombay

and Madras is not as good as salt made by the same process in other countries. As regards the supply of salt in the future, Sir Richard approved of measures taken in the Bombay Presidency by the late Governor, Sir George Lloyd, but advanced the opinion that real efficiency cannot be secured without much greater specialisation in production than has hitherto been considered needful. A supply sufficient in 1881 for a population of 253,000,000 is obviously inadequate for one of 318,000,000, and it is not desirable that India should be dependent to so great an extent upon foreign sources. According to Prof. Rushbrook ("India in 1923") the Government of India propose to provide against any possible failure in Upper India by doubling approximately the annual output from the Punjab mines and Sambhar. So far as the mines are concerned, Sir R. Dane commended this policy, but for reasons he gave he submitted that as regards Sambhar the case is not so clear. The formation of a strong Salt Department appears, he said, to be necessary. Preventive work might be left to the Provincial Excise establishments, but if an adequate supply of good salt at reasonable prices can be assured, he would radically alter the penal provisions of the law and no longer treat as a criminal offence the manufacture of inferior salt for domestic consumption.

In 1917 Mr. Atul Chandra Chatterjee, who for some years previously had filled the office of Registrar of Co-operative Societies in the United Provinces, read a paper on the development of banking and thrift in India. The object of Mr. Rothfeld's paper dealing with the same subject was not, however, to dwell upon the achievements of the village credit society as such, but to present a picture of what has been done by the co-operative movement in the narrower sphere of real banking and especially with the more important application of co-operation to deposit banking in the modern sense. Twenty years ago the mere conception of money in this sense hardly existed in India. Small banking facilities are a primary need of advancing India, and co-operation seems predestined to undertake the duty of supplying such facilities, as is evidenced by the marked progress made in Bombay. The urban banks of the Western Presidency include institutions which, in Mr. Rothfeld's opinion, can face comparison with any similar institutions in any part of the world. One encouraging feature to which Mr. Rothfeld called special attention is the expansion in the use of cheques, stimulated as it had been by a notable concession of Government. Cheques of members of societies are exempted from stamp duty up to a value of 20 rupees. Mr. Rothfeld also referred *inter alia* to the influence of the banks in reducing rates of interest even among money-lenders, an influence of immense value for the prospect of the countryside. As to the future of co-operation, he notes that "with the growing spirit of national feeling and the corresponding gain in self-respect," the number of workers, especially among young men, is noticeably increasing. As regards co-operative marketing, a point touched upon by the Secretary of State for India in the discussion, Mr. Rothfeld was able to say that real progress had been made in his Presidency although it was still only a thirtieth of what it ought to be.

The Indian Industrial Commission which was appointed in 1916 and reported in 1918 included in its many weighty recommendations, the establishment of a service dealing with chemistry, and, as part of the scheme, the formation of a Central Research Institute under the Government of India. The earliest outcome of the Report was the appointment of a strong Committee to formulate proposals for the organisation of the new service and equipment of research laboratories. Professor Jocelyn Thorpe, author of the able and lucid paper dealing with this subject, was appointed Chairman of the Committee and spent several months in the country obtaining an insight into the actual conditions. One effect of his extended tour was to convince him that the Provinces would have nothing to do with the idea of a central research institute as originally proposed, but insisted upon each province having its own research institute. This modification was accepted by the Committee, with the proviso that each Provincial institute confined its activities to its own local immediate industrial needs, leaving a central institute under the Supreme Government to carry out those fundamental researches which underlie the industries of the country as a whole. The selection by the Commission of Dehra Dun for this purpose was endorsed by Professor Joyce's Committee. With regard to the proposed Chemical Service the lecturer dwelt on the use that it would be in not only

providing employment for chemists, but in raising the standard of teaching by absorbing a constant stream of recruits from the University laboratories. The general desire of young Indians for Government employment, with which they are often reproached, he suggests is due, not so much to a desire to obtain "soft jobs," as to a lack of stable conditions, the absence of secure tenure, and the impossibility otherwise of gaining posts yielding an assured income. He sees no reason why recruitment to the new service should not in the near future be wholly Indian.

The interest of the concluding paper in the Indian Section, "The Art of the Pāl Empire in Bengal," which was read by one who has studied the subject on the spot, Mr. J. C. French, lies in the fact that it illustrates a period in Indian Art never before dealt with in Europe. The paper is particularly noteworthy because at the period referred to Bengal under the Pāl dynasty was the chief power in Northern India, and the term "Empire" is, therefore, not inapplicable. It is curious to think that Bengal did not again occupy a similar position until after the Battle of Plassey in the eighteenth century. Oriental art is attracting a steadily increasing amount of attention and its affinity with the latest manifestations of modern art is not unworthy of notice.

Almost the only restriction attached to the annual Sir George Birdwood Lecture is that it must deal with one of the many Indian subjects in which he was interested. Mr. Foster decided on "The Archives of the Honourable East India Company" as the subject of the discourse he was invited to deliver. Previous lectures in the series, he reminded the audience, recalled to our memories Sir George Birdwood's affection for the peoples of India and the services he rendered to that country both in the promotion of its industrial arts and in securing a proper appreciation of indigenous artistic skill alike in painting, sculpture and architecture. It was his (Mr. Foster's) privilege to refer to another field of inquiry to which the many-sided genius of Sir G. Birdwood paid no small amount of attention, with results that still claim our gratitude. His investigations in the seventies of last century contributed largely to the creation, in 1884, of a Registry and Records Department at the India Office, whose accumulation is the second largest in England, approaching the Public Record Office itself in range of subjects. The Department also provides better material for the history of India than can be found in any Indian Record office, as well as containing masses of information about other parts of the Empire and of various Asiatic countries such as China, Japan and Persia. One of the excellent illustrations exhibited on the screen showed the earliest known marine insurance policy, dated 1657. Until two years ago it was believed that a policy of 1681, preserved at Lloyd's, was the oldest in existence. Mr. Foster was able to announce that the British-Indian archives are being increasingly utilised by Indian historians as well as by students of our own race. Sir George Birdwood would have asked no better reward for his labours upon the archives of the Honourable East India Company than that they should form a fresh and durable link between the two countries, India and Great Britain.

In the spring of last year Viscount Burnham visited the West Indies and his statesmanlike and eloquent paper afforded a further proof of the active interest he has since taken in the British islands which form our oldest group of Colonies. In discussing the problems he so carefully studied on his instructive tour, he quoted a Jamaica saying, that the people receive everybody well except their Governors, and he thinks that if such appointments were subject to confirmation by a Cabinet Committee, as in the case now of conferment of titles and honours by the Crown, some disappointments might be more easily avoided. He holds that the representative principle should be applied to the more important islands "instead of always trusting to what Bismarck called the 'spirit of the green table' for the pure—and it is pure—officialism of Downing Street is undoubtedly out of date." He put forward a plea for the constitution of the office of High Commissioner for the British West Indies, the holder to rank immediately after the High Commissioners for the self-governing Dominions, and to be at once a political envoy and a commercial agent. From the commercial point of view alone such an official seems to be needed. When a West Indian merchant or planter makes a proposal involving the assistance of British capital, he is met, said Lord Burnham, by our banking houses with the reply, "Why try to make a British company

when you can get the money so much more easily in New York ?" Lord Burnham also urged revival of the wholesome and historic principle of virtual representation in the Imperial Parliament in the persons of members of the Associated Chambers of Commerce of the British West Indies and the West India Committee.

Under the Empire Settlement Act of 1922, the sum of £3,000,000 per annum is available for fifteen years to assist in peopling the empty spaces of our Oversea Dominions with the right sort of settlers selected from members of our own race. The enterprising Province of Ontario, so efficiently represented by Mr. Noxon as Agent-General in this country, was the first to avail itself of the facilities thus afforded, and it was appropriate, therefore, that he should be invited to tell the Society something about the work that is already being accomplished under the aegis of the Oversea Settlement Committee. Since the passing of the Act the Home Government has entered into agreements with various Oversea Governments by means of which many persons have been already successfully settled in suitable localities, in addition to which certain of the Oversea Governments have schemes of assisted passages of their own. Up to October last the amount spent by the British Government in this way was some £400,000, and the migrants helped numbered 37,295. Both Mr. Noxon and the Chairman of the meeting, Lord Airlie, laid stress on one feature of the Settlement Committee's work, namely, juvenile migration. In some parts of the Empire schemes are being promoted for the migration and settlement of boys from public and secondary schools, an experiment that will be watched with interest.

In his paper on "The Commercial Future of the Backward Races," Mr. Walker gave an interesting account of an organisation initiated by himself on business lines seventeen years ago, when he was a missionary in Papua. The enterprise appears to have met with no little success and might, it is suggested, be equally successful elsewhere if conducted in the same spirit. Apart from the moral and material improvement of the natives, the advantages to be derived are, it is claimed, (1) an abundant supply of raw material from the tropics, (2) the opening of new markets for home manufactures, and (3) a happy and prosperous people, who will become a strength to the Empire.

Considerable interest was aroused by the paper of Mr. Cochrane on the latest addition to the Empire's petroleum resources by the acquisition of the Sarawak oil-field. Although only fourteen years have elapsed since the discovery there of oil in commercial quantities, the new industry has made great strides, the output during 1923 being about 560,000 tons. Amongst British oil-producing countries Sarawak four years previously occupied fifth place; to-day, as Mr. Cochrane observed, it can claim to be by no means a bad second, the lead, of course, being held by Burma with its many years' development. Lord Bearsted, who presided over the meeting at which the subject was discussed, expressed his belief that Sarawak would prove to be a "wonderful field," and in view of that country's immensely important geographical position, he urged the inconceivableness of our ever allowing it to fall into enemy hands. In the course of a weighty speech, his Lordship, as one who has made the development of oil in the British Empire "almost the passion of his life," uttered the strongest possible protest against that development being attempted by Governments. He said he saw, with dismay, the association of the Australian Government with the British Government in regard to Papua and New Guinea. "Hundred of thousands of pounds had been spent and no result obtained."

In 1878 Cyprus came under British administration, though it remained Ottoman territory and its inhabitants Ottoman subjects. The entry of the Turks into the Great War as the allies of the Central Empires resulted in the annulment of the agreement effected by Lord Beaconsfield, and since the end of 1914 the island has been a British Crown colony. This transformation, Prof. Gilbert Cullis pointed out in his admirably comprehensive survey, carried with it extended responsibilities on the part of the Imperial Government, and in order that the well-being of the people of Cyprus may be promoted a knowledge of the new dependency's potentialities has become more than ever desirable. One of the steps taken by the Colonial Office was to commission Prof. Cullis to visit Cyprus for the purpose of reporting upon its cupriferous deposits, and he was thus afforded a unique opportunity

of exploring the country and of acquiring a first-hand acquaintance with its general geology and mineral resources. In concluding his paper he expressed the opinion that another branch of the public service in Cyprus, having the functions and discharging the duties of a Geological Survey and Department of Mines, might with great advantage be added to the local existing administrative machinery.

In the introduction to his fine paper on the Mandatory principle and the British mandates, Sir Frederick Lugard welcomed the opportunity afforded to him of addressing the Society and, through the Society, the publ c at large, on this subject; for, as he remarked, though the British Empire holds nine out of the fourteen mandates and has incurred responsibility for an additional million square miles and some eight million people, less attention seems to have been devoted in this country to the theory and application of this novel experiment in International Law and its present and future problems than has been evoked in the United States, which holds no mandate at all. The Mandates Commission, he suggested, should, in course of time, become a valuable body, whose task is to promote co-operation—which may extend beyond the frontiers of the mandate territory—and to eliminate friction while fearlessly exposing any manifest breach of the mandate. The system, in short, stands as an international acknowledgment that civilisation must be made to mean something higher to the Powers in their dealings with the backward races than the aims and methods of the development syndicate or the assiduous cultivation of new wants to afford markets for commerce. The Chairman of the meeting, Lord Milner, said it seemed to him likely that the mandatory system, so far from obtaining greater extension, was likely, as time went on, to be rather contracted and to prove in many cases a mere transitory stage. Nevertheless, it remained even in its curtailed and more or less mutilated form—he meant as compared with the original big conception—a very important factor in the international situation.

Canada, Dr. Corless reminded us in his long overdue paper, dealing with the mineral wealth of the Dominion, is a country of vast dimensions, seventy times as large as the motherland. It is, therefore, not surprising that the relative mportance of the natural resources of such a huge country is being revealed but slowly even to Canadians. Still less is it to be wondered at that the relative extent of those resources is almost unknown in Great Britain. Considering all the facts, the vast pre-Cambrian area he so fully described may, Dr. Corless said, in time become the greatest and most permanent source of supply of the world's needs in the precious metals.

IV.—Cantor Lectures.

Two short courses of Cantor Lectures, consisting of two lectures each, were delivered before Christmas. The subject of the first was "The Cultivation of Cocoa in British Tropical Colonies." Mr. Samuel Henry Davies, the lecturer, discussed the questions of suitable soil and climate, the selection of seed, the planting out of seedlings and the use of windbelts—a very important point, as the countries most suitable to the cultivation of cocoa are those which are specially liable to hurricanes. The principal diseases and the methods of fighting them were dealt with, as were also the questions of collecting and breaking the pods, fermenting, drying and shipping the beans. The whole subject is one of rapidly growing importance, as will be seen from the fact that the world consumption of cocoa has risen from 100,000 tons in 1900 to 411,000 tons in 1922.

Professor Aldred F. Barker delivered two lectures on "Recent Progress in the Wool Industries." Fresh from a tour round the world he was able to describe with first-hand knowledge the latest developments in breeding in connexion with Australian and Cape wools, and to discuss Colonel Stordy's experimental researches with reference to the Alpaca and Vicuna in Peru—researches of which a preliminary account was given to the Society by Colonel Stordy himself in 1920. Attention was also drawn to Mr. Stefansson's suggestion for the employment on a large scale of ovibos fibre in textile manufacture. In his second lecture Professor Barker reviewed the recent improvements in the principles of the manipulating of the raw materials, and recent mechanical developments, and he concluded an extremely interesting course by sketching the prospective distribution of the wool industry.

Dr. Eric K. Rideal, who gave a course of lectures on "Applications of Catalysis to Industrial Chemistry" in 1921, gave another

course of three lectures on "Colloid Chemistry." In the first he discussed the nature of colloids, and the problems of surface tension and absorption. The work of Hardy and Langmuir was described, and the most recent theories of lubrication were expounded. The second lecture dealt with suspension colloids, peptisation, protection and precipitation. Various industrial processes were discussed, such as peat-drying, the condensation of fumes, and the use of powdered fuels. The subject of the third lecture was the emulsion colloids, their preparation and stabilisation. Attention was given to the chemistry of coal tar disinfectants, milks, various greases and soaps. In conclusion, the permeability of membranes was considered, and the lecturer expressed his belief that the progress of industrial chemistry will depend increasingly on the advances made in this important branch of physico-chemical investigation.

Mr. E. V. Evans delivered three lectures under the title "A Study of the Destructive Distillation of Coal." In the first he discussed the various factors which cause wastage of therms in the forms of gas, and the general principles on which depend high yields of gaseous therms. In the second he dealt with the process conditions affecting the distribution of therms in the forms of gas and tar, and proceeded from this to consider the chemistry and economics of tar cracking. In the third lecture he spoke of the general trend of developments in carbonising processes, and concluded with a discussion of the de-ashing of coal and other factors tending to increase the value of the therm in the form of coke.

V.—Cobb Lectures.

In his course of three lectures on "Certain Fundamental Problems in Photography," Dr. T. Slater Price discussed the chemistry of colloids, with special reference to their division into suspensoids and emulsoids. The latest investigations as to the effect of gelatine on reactions involved in making a photographic emulsion were described, and the progress in producing photographic emulsions generally was considered. The course of lectures was particularly valuable as giving an authoritative account of the recent progress made in our knowledge of the cause of the sensitivity of a photographic emulsion.

VI.—Mann Juvenile Lectures.

Under the Dr. Mann Trust three Juvenile Lectures were delivered in January. The first two, on "Fire and Explosions," were given by Professor W. A. Bone. He gave a short historical account, with numerous experiments, of the work of various chemists from Jean Rey to Henry Cavendish, who have investigated the nature of fire, and subsequently he described the work of Davy, George Stephenson, Faraday, Smithells, Bunsen, and Welsbach. The lecture was fully illustrated with explosions which were much appreciated by the audience.

The Third Juvenile Lecture was given by Mrs. Julia Henshaw, who chose as her subject "Among the Selkirk Mountains of Canada (with Ice-Axe and Camera)." Mrs. Henshaw has travelled much in Canada, and she has brought back with her many lantern slides of little known places. A number of these have been painted by herself with the greatest taste and skill, and her slides of the flora of the Selkirk Mountains are of quite remarkable beauty.

VII.—Albert Medal.

The Albert Medal of the Society for the current year has been awarded by the Council, with the approval of the President H.R.H. the Duke of Connaught, to H.R.H. the Prince of Wales, K.G., "in recognition of Services rendered to Arts, Manufactures and Commerce, as President of the British Empire Exhibition, and by his visits to the Dominions and Colonies."

VIII.—Medals for Papers.

Eleven medals have been awarded for the papers read before the Society during the current session—seven for papers read at the ordinary meetings, two for those read in the Indian Section, and two for those read in the Dominions and Colonies Section.

The awards are as follows:—

Papers read at the Ordinary Meetings :—

Sir Frank Baines, C.V.O., C.B.E., Director of Works, H.M. Office of Works, "The Preservation of Ancient Monuments and Historic Buildings."

Sir Richard Arthur Surtees Paget, Bt., "The History, Development and Commercial Uses of Fused Silica."

Major-General Sir Fabian Ware, K.C.V.O., K.B.E., C.B., C.M.G., Vice-

Chairman, Imperial War Graves Commission, "Building and Decoration of the War Cemeteries."

Frank Hope-Jones, M.I.E.E., Vice-Chairman, British Horological Institute, "The Free Pendulum."

Brig.-General Sir Henry P. Maybury, K.C.M.G., C.B., Director-General of Roads, Ministry of Transport, "The Victoria Dock District and its Roads."

T. Thorne Baker, "Photography in Industry, Science and Medicine."

Mrs. Arthur McGrath (Rosita Forbes), "The Position of the Arabs in Art and Literature."

Papers read in the Indian Section :—

Brigadier-General H. A. Young, C.I.E., C.B.E., late R.A., Director of Ordnance Factories, India, 1917-21, "The Indian Ordnance Factories and Indian Industries."

Sir Richard M. Dane, K.C.I.E., Commissioner, North India Salt Revenue, 1898-1907 ; Foreign Chief Inspector, Salt Revenue China, 1913-18, "Manufacture of Salt in India."

Papers read in the Dominion and Colonies Section :—

C. Gilbert Cullis, D.Sc., M.I.M.M., Professor of Economic Mineralogy, Imperial College of Science and Technology, "A Sketch of the Geology and Mineral Resources of Cyprus."

The Right Hon. Sir Frederick Lugard, G.C.M.G., C.B., D.S.O., D.C.L., LL.D., British Member, Permanent Mandates Commission, League of Nations, "The Mandate System and the British Mandates."

For many years it has been the practice that no medals should be awarded to members of the Council, or to readers of papers who have previously received medals from the Society. Acting on this rule the Council were precluded from considering the following papers :—

G. Albert Smith, "Cinematography in Natural Colours—further Developments."

Alan A. Campbell Swinton, F.R.S., late Chairman of the Council, "Personal Recollections of some Notable Scientific Men."

C. E. K. Mees, D.Sc. (Director of Research and Development, Eastman Kodak Company), "Amateur Cinematography."

The Council desire, however, to express their high appreciation of these papers.

IX.—Swiney Prize.

In accordance with the provisions of the will of Dr. George Swiney, the prize bearing his name was duly awarded in February last, on the eightieth anniversary of the testator's death. Dr. Swiney died in 1844, and in his will he left the sum of £5,000 Consols to the Society of Arts, for the purpose of presenting a prize, on every fifth anniversary of his death, to the author of the best published work on Jurisprudence. The prize was to be a cup of the value of £100, and money to the same amount; the award to be made jointly by the Royal Society of Arts and the Royal College of Physicians.

A meeting of the adjudicators of the prize was held on February 11th, 1924, under the presidency of Lord Askwith, Chairman of the Council.

The adjudicators received a report from the joint Committee of the Royal Society of Arts and the Royal College of Physicians, recommending that the prize should be awarded to Sir Paul Vinogradoff, for his work, "Outlines of Historical Jurisprudence."

On the motion of the Chairman, seconded by Sir Humphry Rolleston, President of the Royal College of Physicians, it was thereupon unanimously resolved : "That the Swiney Prize be adjudged to Professor Sir Paul Vinogradoff, F.B.A., for his work, 'Outlines of Historical Jurisprudence.'"

X.—Annual Competition of Industrial Designs.

In the last Report of the Council it was announced that an Annual Competition of Industrial Designs would be instituted open to two classes of candidates, (*a*) students of British schools of art, and (*b*) any British subjects. Arrangements were made to hold the first competition in June, 1924, and by the kindness of the Director of the Victoria and Albert Museum, the Council have been granted the use of the Museum for this purpose.

In order to add to the attractiveness of the competitions it was decided to offer awards in the form of diplomas, medals, money prizes, and, if funds permitted, travelling scholarships. An appeal for assistance was issued, with the gratifying result that at the first competition the Council were enabled to offer over £1,000 in prizes and travelling scholarships.

This year the competition is being held in the following sections : Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. The particulars and con-

ditions of the competition were issued in December, 1923, and were very widely circulated. Great assistance was also rendered by the Press, both technical and non-technical, in making known the competition.

The last date for receiving entries was June 9th. Over 1,300 designs have been received from about 500 competitors.

It has been the aim of the Council and of the various committees appointed by them to carry out this competition, to ensure that any designs approved by them should bear evidence that the designers possess not only exceptional artistic ability, but also a sound and practical knowledge of the materials and processes of their trades. The various committees consist mainly of representatives of important manufacturing and commercial firms, and the judges nominated by them will not be likely to overlook the question as to whether a design submitted is suitable or not for the materials for which it is intended.

After the awards have been made, it is intended to exhibit a number of selected designs at the Victoria and Albert Museum, and subsequently at suitable centres outside London, where they will be brought to the notice of manufacturers likely to be specially interested in them.

As soon as the Judges have completed their work it is proposed to issue a full report on the competition, which will be published in the *Journal* and circulated widely among manufacturers and competitors. It is hoped that this report will be of great service to young designers and to the industries concerned. The judges will be able to criticise the work submitted, to show wherein it is defective, either from the artistic or practical point of view, and to point out the lines along which development is to be encouraged.

XI.—Examinations.

The number of entries for this year's examinations again constitutes a record. For the April series the figure was 27,273, for the June series 43,838, making a total of 71,111, as against 68,241 in 1923.

In order to show their growth the figures are given for the last six years, for 1914, which was then the record year, and also for 1916, which shows the effect of the war on the entries :—

Year.	Number of entries.
1914	37,974
1916	25,968
1919	34,173
1920	54,010
1921	55,182
1922	60,331
1923	68,241
1924	71,111

The examinations are held in most of the principal cities and towns of Great Britain and Ireland, and in nearly all cases are conducted and supervised by the Local Education Authorities, to whom the Society is greatly indebted for the efficient manner in which these duties are carried out.

There were 363 Centres for the April Examinations, and 347 Centres for those in May and June. The County of London, where the Examinations are under the control and supervision of the London County Council Education Committee, is only reckoned as one Centre, though under this head are included entries from nearly two hundred Evening Institutes, Polytechnics, Proprietary Schools, etc. The number of entries for the County of London was 3,468 in April, and 13,147 in May and June.

The liberality of the Worshipful Company of Clothworkers has enabled the Council, as in past years, to offer the usual silver and bronze medals. These medals are very highly valued by the successful candidates, and they contribute not a little to maintain the high standard of the examinations.

The results of the First Division of the Examinations, held in April, have already been communicated to the candidates, and those of the June Division will be announced as soon as possible.

A report giving full details of the year's Examinations will be published in the *Journal*, as usual, at a later date.

XII.—Oral Examinations in Modern Languages.

The Oral Examinations are still in progress in various parts of the country. Particulars will be given in the annual report on the Examinations.

XIII.—New Council.

The Vice-Presidents retiring under the ordinary regulations are : Sir Charles Stuart Bayley, Lord Bearsted, Mr. Edward Dent, Lord Montagu of Beaulieu, and Mr. Carmichael Thomas (who is nominated as

a Treasurer in place of Lord Blyth). In their places the Council recommend Captain Sir Acton Blake, Lord Blyth, Sir Edward A. Gait, Lord Leverhulme, and Sir Philip Magnus.

The four Ordinary Members of Council retiring are: Mr. Charles Frederick Cross, Sir Edward Davson, Sir Philip Magnus (who is nominated a Vice-President), and Mr. Ernest H. Pooley. In their places the Council recommend Sir Frank Baines, Sir Archibald Denny, Colonel Sir Arthur Holbrook, and Sir Charles C. McLeod.

XIV.—Obituary.

The Council have to regret the loss of a certain number of distinguished Fellows who have died during the year.

Sir William Duke was a member of the Council, and Chairman of the Indian Section Committee from 1916 to 1920.

Dr. W. H. Maw had served on the Council since 1911, and was one of the Society's Treasurers at the time of his death.

Sir Henry Evan M. James was for many years a valued member of the Indian Section Committee.

Sir Henry Kimber, who died at the age of ninety, had been a Fellow of the Society for forty-seven years.

Mr. F. T. Waring had been a Fellow of the Society since 1892, and he frequently took part in the discussions.

Among other notable Fellows who have died during the last twelve months may be mentioned Sir John Stewart Clark, Mr. H. S. Freeman, Mr. T. Jenkinson, Mr. W. J. Leonard, Sir Robert Park Lyle, Mr. Paul Gregory Melitus, Mr. G. W. Taylor, Mr. J. H. Tritton, Mr. A. F. Wenger, and Mr. C. J. Wild.

XV.—Finance.

At the close of the Council's last Annual Report the hope was expressed that the Financial Statement for 1923 would show a further improvement over that for 1922. It is very satisfactory to learn that this hope has been fulfilled. According to the Financial Statement published in the *Journal* of June 20th, the excess of income over expenditure in 1923 was £1,383 13s. 8d. as compared with £596 17s. 4d., the figure for the previous year. This improvement is due generally to very careful supervision in the case of all matters of expenditure, and specially to the economies effected in the miscellaneous printing of the Society.

While the Council feel that they have good reason to be satisfied with the situation shown by the Income and Expenditure Statement for last year, they would remind Fellows that there remains a considerable deficit to be made up in the Building Fund Account. The cost of purchasing and renovating the Society's House was about £50,000, towards which, so far, nearly £43,000 has been subscribed, leaving £7,000 still to be raised. Many Fellows have contributed to this fund with great generosity, but about *ninety per cent.* of them have not yet subscribed at all. The Council would earnestly appeal to those whose names have not yet appeared in the subscription lists to assist them in clearing off the debt either by subscribing themselves or by endeavouring to secure fresh support for the Society among their friends.

The Chairman (Lord Askwith) moved the adoption of the Report, which showed that there was no fault to find with the Society, and that it was continuing in a progressive and flourishing manner. The finances had improved, and the papers and lectures had been of a very high standard. The fact that the proceedings of the Society were published throughout the wide world by means of the weekly journal was fully appreciated by the distinguished people who had read papers before the Society. The Council had under consideration proposals for improving the Journal, which he hoped would be of further advantage to the Society. He also mentioned that the Society had been left a legacy of about £10,000 (the exact amount had not yet been determined) to found a Trust for the advancement of the Science of Navigation and the scientific and educational interests of the British Mercantile Marine.

Dr. J. Augustus Voelcker said he had much pleasure in seconding the adoption of the Report. He was sure all the Fellows would be struck with the excellence of the papers and lectures provided during the past session. He could assure them that their interests were well looked after, and that the Council in their turn were encouraged by the continued appreciation and support given by Fellows to the Society's work. He referred to the large increase in the number of candidates who had entered for the examinations and to the good work which was being done in this direction.

The adoption of the Report was then agreed to.

The Chairman then proposed a cordial vote of thanks to Mr. G. K. Menzies (the Secretary), Mr. S. Digby (the Secretary of the Indian and Dominions and Colonies Sections), Mr. George Davenport (the Chief Clerk), Mr. J. H. Buchanan (the Accountant and Examinations Officer) and to the other

officers of the Society for their services during the year. The Secretary's work had been continuous throughout the session, and he was always looking out for opportunities to benefit the Society. Their thanks were also due to Mr. Digby for his remarkable talent in obtaining papers dealing with Indian and Colonial subjects.

MR. CARMICHAEL THOMAS said he had great pleasure in seconding the vote of thanks. They all saw the results of Mr. Menzies' work in the pages of the Journal, and he could assure the Fellows that the Council very greatly appreciated the Secretary's services.

THE SECRETARY returned thanks for this expression of confidence in himself and in the other officers of the Society.

The ballot having remained open for half-an-hour, and the scrutineers having reported, the CHAIRMAN declared that the following had been elected to fill the several offices. [The names in *italics* are those of Fellows who have not, during the past year, filled the office to which they have been elected.]

PRESIDENT.

H.R.H. The Duke of Connaught and Strathearn, K.G.

VICE-PRESIDENTS:

Sir Thomas Jewell Bennett, C.I.E.
Captain Sir Acton Blake, K.C.M.G., K.C.V.O.
Lord Blyth.
*Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.
Marquess Curzon of Kedleston, K.G., G.C.S.I., G.C.I.E.
Earl of Durham, K.G., P.C., G.C.V.O.
Peter MacIntyre Evans, M.A., LL.D.
Sir Edward A. Gait, K.C.S.I., C.I.E.
Lord Inchcape, G.C.M.G., K.C.S.I., K.C.I.E.
Sir Herbert Jackson, K.B.E., F.R.S.
Lord Leverhulme.
Lt.-Col. Sir Henry McMahon, G.C.M.G., G.C.V.O., K.C.V.O., C.S.I.
Sir Philip Magnus, Bt.
Senator Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.
Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S.
John Slater, F.R.I.B.A.
James Swinburne, F.R.S.
*Alan A. Campbell Swinton, F.R.S.
J. Augustus Voelcker, M.A., Ph.D.
Sir Philip Watts, K.C.B., LL.D., F.R.S.
Sir Aston Webb, K.C.V.O., C.B., P.R.A.
*Sir Henry Trueman Wood, M.A.
Sir Alfred Yarrow, Bt., M.Inst.C.E., F.R.S.

ORDINARY MEMBERS OF THE COUNCIL.

Sir Frank Baines, C.V.O., C.B.E.
A. Chaston Chapman, F.R.S.
Sir William Henry Davison, K.B.E., D.L., M.P.
Sir Archibald Denny, Bt., LL.D.
Sir Robert Abbott Hadfield, Bt., D.Sc., F.R.S.
Rear-Admiral James de Courcy Hamilton, M.V.O.
Col. Sir Arthur Holbrook, K.B.E.
Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.
Major Sir Humphrey Leggett, D.S.O., R.E.
Sir Charles C. MacLeod.
Sir George Sutton, Bt.
Sir Frank Warner, K.B.E.

TREASURERS.

Lord Askwith, K.C.B., K.C., D.C.L.
Carmichael Thomas.

SECRETARY:

George Kenneth Menzies, M.A.

* *Nominated by H.R.H. the President.*

On the motion of the CHAIRMAN a vote of thanks to the scrutineers was carried unanimously.

MR. CARMICHAEL THOMAS proposed a very hearty vote of thanks to the Chairman for his services during the past year. Speaking as a Member of Council of more than twenty years' standing, he said Lord Askwith had proved to be an ideal Chairman. He had gained the respect and affection of all the Members of the Council, and the speaker expressed the hope that in course of time Lord Askwith might be re-elected to the office.

SIR THOMAS JEWELL BENNETT, C.I.E., seconded the motion. The Society owed its wonderful prestige in great measure to the fact that it had always been able to draw upon the most notable men of science and letters and in public life for its Chairmen of Council. Lord Askwith had fully kept up the high standard of those who had held the office in the past, and they were very grateful to him for all the services he had so willingly rendered to the Society.

LORD ASKWITH thanked the mover and seconder of the vote of thanks, as well as the meeting for the manner in which it had been received. Chairmen of Council held office as a rule, for two years, and at the expiration of that period they retired. He was vacating the post in accordance with the By-Laws with considerable regret, because of his interest in the Society's work. He hoped that next year they would have a Chairman of Council who would bring before them in his inaugural address some interesting matters of which possibly some of them were at present ignorant. He said he could not divulge his name until after the next meetin of the Council.

The meeting was then adjourned.

SOCIAL CONDITIONS IN PORTUGAL.

The first fact which forces itself on the attention of the observer of social conditions in Portugal, writes H.M. Consul at Lisbon, in his recent annual report, is the widespread illiteracy. Three out of four of the population of six millions can neither

read nor write. Thus not only are they bookless but even the Press cannot reach them. National schools exist for those who choose to attend—a number which for various reasons, including prejudice and superstition, is very small. From time to time efforts are made to introduce a compulsory system of education—the latest attempt was made in the summer of 1923—but the Bill was shelved.

But though primary education seems to make little or no progress there are other influences tending to develop the mental outlook and character of the people. The cinema, for instance, has become the chief recreation of the humbler town dwellers, to whom—though the popular style of film is, as a rule, not very edifying—it presents scenes and manners of other countries which otherwise could be known to but few.

Another innovation, which is bound to react on the national character, is football. To many thousands of Portuguese youths, football is to-day almost a religion. Not only does it provide a healthy occupation where in many cases none existed before, but it tends to foster the team spirit and sense of fair play which is so valued a social asset in England.

From a material point of view, there is no doubt that the condition of the people as a whole has greatly improved in the past few years, owing to the increase in the level of wages, which have risen considerably more than the cost of living.

THE SILK BREEDING INDUSTRY IN HUNGARY.

The Hungarian Government is taking all possible steps to revive the silk nursery, which was completely destroyed during the communist sway. According to the *Silk Journal*, the breeders receive worms, foliage and written instructions free of charge. In all schools and institutes notices are posted explaining silkworm breeding, and it has lately been decided to show educational films in all cinemas in March and April each year. The Government has also sent out instructors and technical experts to different parts of the country.

It is worth mentioning the Szekszáder Microscopical Institute (possessing about 265 instruments), which supervises the breeding. The butterflies, after laying their eggs, are crushed and tested for bacteria, with the result that the eggs put on the market are faultless and of such good quality that even Japan obtains some of her supplies from Hungary.

As a result of the efforts of the Government, the yearly production has increased since 1919 from 35,000 kilogrammes to 402,000 kilogrammes, and the number of private breeders from roughly 2,500 to 15,000. At present the home demand absorbs all the cocoons; and although to-day Hungary imports a certain quantity, especially from Italy and Bulgaria, for working up, it is hoped that in a few years, with further support from the Government, there will be a surplus for export purposes in the silk trade.

NOTES ON BOOKS.

RICE. By Edwin Bingham Copeland. London: Macmillan & Co., Ltd. 20s. net.

Rice is the world's greatest crop. The normal annual production is estimated by the International Institute of Agriculture at the amazing quantity of four hundred and forty billion pounds of rough rice. It is probably the staple food of the majority of the human race; and the number of cultivated varieties probably exceeds that of all other grains combined.

In view of its immense importance it is extraordinary to find that hitherto rice has not formed the subject of book treatment in any Western language. A great deal has been written about it, but the information is so scattered that it is practically inaccessible to those who require it most. Great credit is therefore due to the author of this work, who, as Professor of Plant Physiology and Dean of the College of Agriculture in the University of the Philippines, brings to the task a ripe scientific knowledge as well as a practical acquaintance with the troubles of the rice cultivator.

In this book of 350 pages, Professor Copeland treats of the whole subject of rice from A to Z. Chapter I gives a concise but adequate account of the botany of the plant. Chapter II deals with climate, soil and water, and this is followed by an extremely interesting chapter on the diseases and pests of rice. Although rice is probably the most widespread of crops, it is remarkable, writes Professor Copeland, "that it has never, so far as we know, been destroyed as an industry of any country as coffee has been wiped out in several, and is not even known to be generally subject to any such serious damage from an enemy as wheat, for example, has suffered from its rust. The explanation is probably not that rice is more immune than wheat, in its nature, though this is possible, but is rather to be found in the different methods of culture. Commonly transplanted, and always harvested by hand where its culture is old and intense, rice has been comparatively easily and naturally guarded against epidemics, by reasonable care and without recourse to any scientific methods, such as disinfection or the use of the enemies of the pests."

In subsequent chapters the author deals with the varieties of rice; rice in the United States, in the Philippines and in other lands; and the uses of rice. He also describes the various kinds of machinery used in rice cultivation, and discusses when it is advisable to employ machinery and when it is better to trust to hand labour.

The text is enriched by twenty-seven illustrations. Of these perhaps the most striking are the frontispiece and the picture facing page 242, both of which

depict the "Igorot" rice terraces in Northern Luzon. Here the mountains on both sides of the valley have been carved into terraces, while walls and dams have been built to contain the necessary water. The amount of labour expended on the work is almost incredible, and it is all the more wonderful because it has been carried out by people who in most respects are not very far removed from savagery.

GENERAL NOTES.

THE SILK JOURNAL.—It is remarkable that the silk industry, which employs nearly 35,000 workers engaged in the manufacture of silk goods, and a much greater number engaged in the distribution, making-up and ancillary occupations, has existed for so many years without a paper devoted specifically to its interests. That reproach is now to be removed from the industry. The first number of the *Silk Journal* has just appeared, and it is to be published monthly. The editor is Mr. Frank Nasmith, a member of the council of the Textile Institute. The Journal is extremely well got up, it contains a number of excellent articles, and does credit to the enterprise of the editor and to the printers.

SILK PRODUCTION IN THE EMPIRE.—Professor H. Maxwell-Lefroy, writing in the *Silk Journal*, states that silk is not now one of the important products of the Empire; the silk, that is the raw material used in the preparing, spinning and weaving factories, in England, that is worn in all parts of the Empire, is, with the exception of part of India's consumption, produced in other countries. In 1913, out of 960,000 lb. of raw silk consumed in manufacture in England, only 25,000 lb. was from Empire sources; in 1922, out of 976,000 lb. (worth nearly £2,000,000) 78,000 lb. was from Empire sources. This condition is not going to remain; silk is being produced experimentally, and in a few years it will be an important production.

STATE AID TO SERICULTURE IN ALGERIA.—Renewed efforts are being made to stimulate silk-worm culture in Algeria, writes the United States Vice-Consul at Algiers. The Government will distribute free silk-worm eggs, and the governing board of the botanical gardens in Algiers will attend to the destruction of the chrysalides, and will purchase the cocoons at current prices, owing to the difficulty experienced by small producers in carrying out these operations. The Government will also allow a bounty of 60 centimes per kilo of cocoons in addition to the purchase price.

COAST EROSION.—The Minister of Agriculture, Mr. Buxton, was recently asked in the House of Commons whether any careful yearly record is kept of the effects of coast erosion, so that counter-action may be taken without delay if the occasion warrants it. Mr. Buxton stated that the only information which normally reaches his Department from time to time on this subject is in respect of those areas where there is a drainage authority possessing statutory powers to carry out sea defence works. He added that no direct action is taken by the State for countering coast erosion, and that the Royal Commission, which reported fully on the subject in 1911, suggested that the carrying out of sea defence works was not a matter for public expenditure, and, moreover, found that more land was being recovered from the sea than was being lost.

PROFIT FROM SILVER FOXES.—The silver fox farming industry on Prince Edward Island (according to the Canadian Official Press Bureau) is now yielding an annual cash revenue of over £400,000 and producing excellent profits for the farmers. Pelts sent from the island to the recent fur auction sale at Montreal realised the highest prices there. Some fine skins obtained as much as £70 to £90. All prices, however, were exceptionally good. Last year about 2,600 animals were sent from the island for breeding purposes to American points alone, and smaller numbers were sent to Scotland and Germany.

FEMALE LABOUR IN CANADA.—The "Canada Year Book, 1922-23," shows that in 1891 11.07 per cent, in 1901 12.01 per cent., in 1911 14.31 per cent. of the female population 10 years old and over were gainfully employed—an increase from one-ninth to one seventh of these ages during the 20-year period, a rate of increase, which in view of the labour conditions of the war and reconstruction period will, it is reported, probably be found to have been maintained in the present decade. "It is significant," says the Year Book that among females the age period during which there is a maximum of gainful employment is shown by the census to be that from 15 to 24 years inclusive. Of the female population of these ages 27.78 per cent. were in 1911 gainfully employed, a percentage which fell to 12.14 per cent. for the period 25 to 64 years inclusive. As every employer of female labour knows, the decline is due to the absorption of female labour by marriage and home duties."

VICTORIA AND ALBERT MUSEUM.—Mr. Eric Robert Dalrymple Maclagan, [illegible], has been appointed Director and Secretary of the Victoria and Albert Museum in succession to Sir Cecil Harcourt Smith, C.V.O., who retires on September 11th. Mr. Maclagan joined the staff of the Museum in 1905 and has been Deputy Keeper, Department of Architecture and Sculpture, since 1921. *The Times* says:—"He has shown in various articles and other publications that he possesses a refined and discriminating taste as well as a profound knowledge of art."

Journal of the Royal Society of Arts.

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FRIDAY, JULY 11, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICE.

INDIAN SECTION.

MONDAY, 30th JUNE, 1924; RT. HON. THE EARL OF RONALDSHAY, G.C.S.I., G.C.I.E., in the chair.

A paper on "The Art of the Pal Empire in Bengal" was read by MR. J. C. FRENCH, I.C.S.

The paper and discussion will be published in a subsequent number of the *Journal.*

PROCEEDINGS OF THE SOCIETY.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 12TH, 1924.

SIR HERBERT JACKSON, K.B.E., F.R.S., in the chair.

The paper read was :—

PERSONAL RECOLLECTIONS OF SOME NOTABLE SCIENTIFIC MEN.

(Illustrated by photographs).

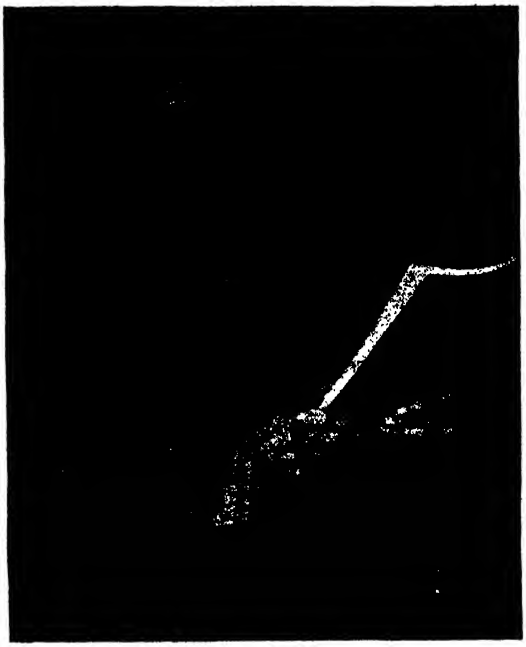
By ALAN A. CAMPBELL SWINTON, F.R.S.

(Late Chairman of Council).

Some years before the war I was giving a Friday evening discourse at the Royal Institution upon Electricity Supply. Some of you may know that the methods adopted at the Royal Institution on Friday evenings are rather peculiar. The Chairman takes his seat before the lecturer enters the lecture hall, but, save that he sits in the Chair, the Chairman takes no part in the proceedings. When the lecturer comes in, as he does when the clock strikes one—the Royal Institution clock is a very special one, inasmuch as it never strikes anything but one—he [illegible]ays immediately followed by the resident Professor, who comes in by another door. The resident Professor for many years was the late Sir James Dewar. On the occasion in question, while we were waiting outside the lecture theatre for the clock to strike, Sir James Dewar said to me, "You see, I am here to do my duty." "What is that ?" I asked. "My duty," he said, "is to see that the lecturer does not run away." "Why," I asked, "has that ever occurred ?" "Oh, yes," he replied. "Professor Wheatstone was left alone on one occasion, and just before the lecture was about to begin he got frightened and ran away and hid himself, and Faraday had to give an extempore lecture in his place."

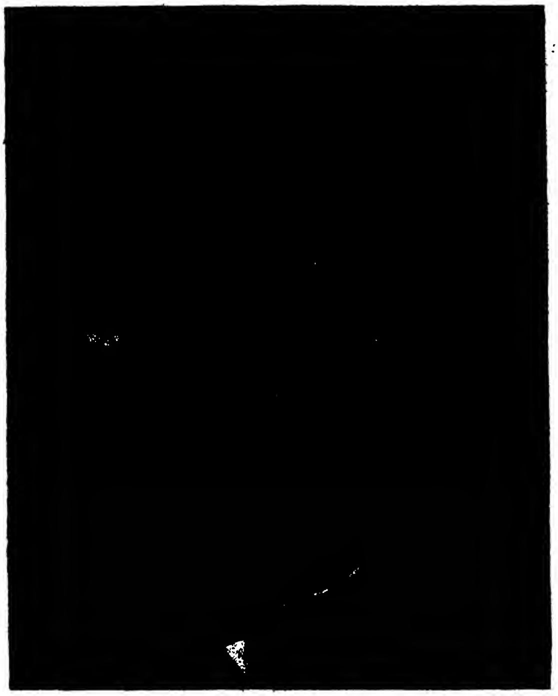
Well, I have had no chance to run away to-night, although I might have wished to do so ; for when this lecture was announced, a very well-known Professor of Chemistry expressed his surprise at its nature, and said that he had no idea that I had any experience of giving lectures of a biographical kind. Well, let me confess at once, I have no such experience, at any rate before an audience like this, and this lecture is an experiment "*in corpore vili*" where this audience are the victims.

The first scientific man I ever met was Professor Huxley, the great protagonist of Darwinism. In 1877 he happened to be sitting on a Royal Commission on Scottish Education with my father, and my father asked him to stay for a few days at my old home at Kimmerghame, in Scotland. His visit caused some considerable stir in the neighbourhood. I can almost remember the actual words of our head gardener, who was a very intelligent individual, when he said he could not understand how Mr. Swinton, a God-fearing man, an Elder of the Kirk, and a member of the General Assembly, could ask to his house such a notorious unbeliever. I remember also that our old Scottish nurse was very much concerned about the visit, and after family prayers, which we used to have every morning, and at which Professor Huxley was present, this dear old lady in a tremulous voice asked me, as I had been kneeling next to the Professor, if I had noticed whether he had joined in repeating the Lord's Prayer. This shows how times have changed, for I do not think that men like Huxley are looked at askance in the same way now.



Lord Armstrong.

It was not until some years later that I met other scientific men. I was apprenticed to Lord Armstrong (then Sir William Armstrong) and in 1882, I entered his celebrated works at Elswick, in Newcastle-on-Tyne. Sir William Armstrong was a very remarkable man. He is chiefly known for his invention of the hydraulic crane, accumulator and other machinery and for the famous Armstrong gun, but he was originally a practising solicitor. He first achieved fame by investigating some curious electrical phenomena which had been observed at Cramlington Colliery, near Newcastle, in which electrical sparks were obtained from the steam escaping from the safety valve. Due to this investigation he invented what is known as the Armstrong hydro-electric machine, and attracted the attention of Faraday, and was elected a Fellow of the Royal Society. He continued, however, in the practice of the law until he was 35 years of age, when he turned to engineering, and started the famous Elswick Works. At a later period, during the Crimean war, his attention having been turned to the very deficient arrangements that then obtained with regard to gunnery, he developed his famous gun. Of course, when I first came in contact with him he was a comparatively old man—72 or 73—but he lived until he was 90 years old, and during the latter part of his life I used to see him fairly frequently, because he took again in his old age to his original electrical hobbies, and I, who lived in London, used to get his apparatus made for him and used to go and see him at his beautiful home, Cragside, in Northumberland. The illustration is a photograph which I took of him in 1891, when he was 81 years of age. I remember him teling me that he had been delicate as a boy, and that when he married, at the age of 25, he could not get any Insurance Company to insure his life because they said he had heart disease. He was very original and precise in his ideas, and on one occasion he told me that he thought all poetry to be poor stuff. He had never received any training as an engineer, and he could not draw at all. When I had the task of getting things made for him it was somewhat of a difficulty for him to describe what he wanted without resorting to drawing, but of drawing he was quite incapable. For an engineer not to be able to draw is certainly very peculiar. He was a great organiser and a shrewd judge of character. Though no mathematician, he had a remarkable faculty for intuitively getting to the bottom of things. He was also a pioneer in many directions. His house at Cragside was one of the first houses to be lighted by electricity, and he also had in



Sir Andrew Noble.

his grounds what I think was the first hydro-electric installation in this country and the first transmission of considerable quantities of electric energy over a fairly long distance.

It was in 1887 that I took the photograph of Captain (afterwards Sir Andrew) Noble, who was Lord Armstrong's right-hand man for many years, and afterwards succeeded him as Chairman of Messrs. Armstrong, Whitworth & Co. Noble was a profound mathematician and a living encyclopedia on all subjects, besides being the hardest working man I ever came across. He must have had a wonderful constitution, as he used to work fifteen to eighteen hours a day; then travel up to London by night and do the same thing next day. Like Lord Armstrong, who received the Albert Medal of this Society in the year 1878, Sir Andrew Noble received the same distinction in 1909. Lord Armstrong used to say that there was only one worse draughtsman at Elswick than himself, and that was Sir Andrew Noble.

I next show a group of scientific men taken by myself at Sir Andrew Noble's house at Jesmond, Newcastle, on the occasion of the Newcastle Meeting of the British Association in 1889. In addition to Sir Andrew himself, it includes Lord Kelvin, Professor Osborne Reynolds, who had a theory of matter to the effect that everything consisted of hard corpuscles, illustrated in the picture by a heap of billiard balls, and Sir Frederick Abel, the well-known chemist, who was one of the inventors of cordite and of the Abel fuse and one of the earliest people to put gun-cotton into practical use. He was a good friend to this Society, and was at one time Chairman of its Council. Another figure in this picture is Sir Frederick Bramwell, who also took great interest in this Society. Again, we have Sir William Abney, the great photographic expert, Sir George Baden-Powell, the elder brother of the founder of the Boy Scouts, and Captain Casella, of the Royal Italian Navy. There are many things that one could say about some of these people.

First of all let me say a few words about Sir Frederick Bramwell. He was a great character, and there are many stories told about him. I was told only the other day that he was the actual inventor of the well-known story which makes one man go up to another and say, "Have you heard? Rothschild has bought the *Times*." "Oh, is that so? What did he pay for it? It must have been a large sum." "Oh no, only 3d." His advice to after-dinner speakers to

Prof. Osborne Reynolds. Capt. Casella. Lord Kelvin. Sir F. Bramwell. Sir G. Baden-Powell.
Sir Andrew Noble. Sir Frederick Abel. Sir William Abney.

"Get up, speak up, and shut up," was at any rate sound. He had an elder brother, Lord Bramwell, a judge, who divided liars into four classes—liars, damned liars, expert witnesses, and "my brother Fred." This recalls the riddle of Biblical connexion that was invented in the early eighties, after a celebrated patent law action, concerning the telephone, at which there was much contradictory expert evidence. "Why did Ananias stand forth?" was the question, and the answer, "Because Bramwell stood first, Thomson stood second, Hopkinson stood third, so Ananias could only stand fourth."

Sir Frederick Bramwell was a great expert witness and he was also something of an actor. On one occasion when it was necessary to his side of the case to prove that a minute was a very long period of time, he suddenly, while giving his evidence, stopped short in the middle of a sentence. Nothing happened, all was silence and one could have heard a pin drop; counsel fidgeted with their papers, the Committee thought that Sir Frederick must have been taken ill; we know how interminable a minute can seem under such circumstances, and when the minute had expired, he merely said, "I have been silent for precisely one minute." It was a very effective way of showing how long a period one minute is. On another occasion he paralysed a cross-examining counsel by saying that he would answer counsel's question, if counsel could tell him what was the distance between Westminster Bridge and Christmas. Another story is this: He was employed by someone on special business and sent in his bill, which the client thought was moderate. This being so, after a time his client employed him again and got a "whopping" bill. Meanwhile, Sir Frederick Bramwell had been elected a Fellow of the Royal Society, and had received the honour of Knighthood, so that when the client wrote and expostulated, Bramwell replied, "You should have noticed those three letters after my name, F.R.S., they mean 'fees raised since' and besides that, you have now got to pay for 'Knight' work."

Bramwell, as can be seen from his portrait, was built on a generous scale with portly dimensions and a very fine presence, hence it was not out of place when someone in proposing a vote of thanks alluded to him as "our worthy member who so fittingly fills

and so fittingly fits the presidential chair!"

Next we come to Lord Kelvin, one of the most remarkable men of the last century. The first time I ever met him was when I was taken to see him in his laboratory in 1882, when he had just lighted up his house by electricity. I suppose I must have suggested that electrical engineering might have a great future, and be a good business to take up, but he replied, "Oh no, it will never be more than a plumber's job." And he gave similar advice to other people. Only to-day I was told a story by Sir Joseph Thomson, which rather illustrates the same aspect of his character. Lord Kelvin was asked to join the Marconi Company in its early days, and in telling someone else, he said, "Yes, I have accepted, but I made it a condition that their capital is not to be more than £100,000, because no wireless telegraph company can ever want any more money than that."

It is curious that this great man was not able to foresee any better. Lord Kelvin never read any books, at all events in his later years. He used to get all his information by talking to people. He was a most kindly man. I remember one story about him which was told me by Sir William Ramsay, who was a student in Lord Kelvin's laboratory. On one occasion Lord Kelvin wished to charge up a very large Leyden jar that he had. Now a charged Leyden jar is a thing with which one has to be careful; Lord Kelvin, unfortunately, took hold of the Leyden jar by the knob and charged it up, and after he had done so, he suddenly realised that he now could not put it down. If he had placed it on the floor or on a table he would have received a severe shock, and if he had dropped it he would have smashed it to pieces. I think they had to get a net or something of that kind into which Lord Kelvin was able to drop the Leyden jar, but the spectacle of the great man holding on to the jar of which he dared not leave go must have been a funny one. Lord Kelvin also received the Albert Medal of this Society in 1879.

I will next refer to Alexander Graham Bell, the original inventor of the telephone, which he perfected in 1876. In the United States they always claim Bell as an American, but as a matter of fact he was a Scotsman, born in Edinburgh, in 1847, and as he told me himself, he invented the idea of the telephone in Canada, though he did not get it actually made until he went to the United States, where later, he became naturalised as an American citizen. He was a remarkable old man, and he did other things besides inventing the telephone. As some of you may remember, the phonograph, as originally invented by Edison, in which the sounds were recorded by indenting a piece of tinfoil, was a very crude affair. Bell received in connexion with the telephone a money prize of considerable value, and he told me that he determined to utilise this amount in doing something useful. After consideration, what he set himself to do was to improve Edison's phonograph, and it was Bell, in conjunction with a friend of his called Tainter, who conceived the idea, instead of indenting tin foil, of cutting a record with a sharp cutter upon wax, which is the basis of all modern phonographic and gramophone records. Bell was no business man himself, and I presume that, had he been left to his own devices, he would never have made any money out of the telephone. I do not think he even realised that there was any commercial value in it. He had, however, married a lady who was deaf and dumb; and her father, Mr. Hubbard, was a very clever business man, with the result that Bell's father-in-law, by putting the telephone to commercial use, made a very large fortune, which in time became Mrs. Bell's. Bell, therefore, died the husband of a very rich woman, the money having been made through his own invention, and yet not made by himself. Bell received the Albert Medal of this Society in 1902. I met Graham Bell in London, in 1907, when he sketched for me his recollection of his first telephone. He was a very modest man, and on that occasion he said to me, "I do not pretend to be an electrician, in fact, my friends tell me I could not be one, because if I had been one I should have known beforehand that my telephone would never work."

Mr. Edison improved upon the Bell telephone as far as the transmitter is concerned. When we use the telephone to-day, the receiving instrument which we put to our ears is practically exactly as Bell left it, but the ordinary microphone transmitter is partly the invention of Mr. Edison. Of course, Mr. Edison did more than improve the telephone transmitter. He invented the phonograph, which is a notable achievement, and he was one of the original makers of successful incandescent electric lamps. It is a curious thing to look back now to the

early days of the incandescent electric lamp, and to remember how Edison and Swan made filaments out of such an intractable material as carbon. Mr. Edison tried platinum, iridium and other metals, and then he had recourse to carbon. Now, of course, everybody has gone back to the metallic filament. Tungsten in a metallic form, I suppose, was not known in those early days of Swan and Edison.

Sir Joseph Swan was contemporaneous with Mr. Edison—in fact, even before him—in the invention of the carbon filament electric lamp. Perhaps I should say they were neck and neck when it came to commercial lamps, but as a matter of fact it was Swan who showed electric lamps in a lecture at Newcastle four or five years before Edison was in the field, though nothing came of it, and it found no commercial application. Swan was also one of the inventors of the carbon process of photography. He was President of the Institution of Electrical Engineers and received the Albert Medal of this Society in 1906. With his long silver hair, and flowing snowy beard he was a most picturesque person.

David Hughes was one of the original inventors of type-printing telegraphs. The ordinary tape machine at clubs and hotels is very much based on his work. He invented his printing telegraph while in America, but he was a Welshman born in London, and went out to America at an early age. He is usually known as Professor Hughes, but he was a professor, not of engineering or physics, but of music. After having got his telegraph taken up all over the continent, he came back and lived in this country. In 1878 he invented the microphone, and, as we now know, he made experiments in wireless telegraphy some years before the Hertzian waves had been discovered by Hertz. Hughes lived in a small flat off the Tottenham Court Road, and he and his wife—a quaint old couple—lived so economically that I do not suppose they ever spent more than £500 a year. I remember once suggesting to him on a wet night that I should fetch a cab to take him home, and he said to me, "Cab! Oh no, I cannot afford cabs." Shortly afterwards when he died he left something like three-quarters of a million sterling to the London Hospitals. After his death, Mrs. Hughes, who was an American, went back to live in the States, and two or three years ago she died and left her husband's notebooks to the British Museum, which did not quite know what to make of them. Finally, the Museum authorities sent them to me to advise whether they ought to be accepted. I happened to know that Hughes had made experiments in wireless telegraphy which had never been published, and I thought it might be possible to find something in those notebooks. In this I was successful and I told the British Museum that I thought they ought to be preserved, as I found in them a complete account of Hughes's experiments in wireless telegraphy. He had evidently carried on wireless telegraphy up to distances of some hundreds of yards. He had a clockwork apparatus by which he sent wireless signals, and he used to walk down the street with a telephone connected to some sort of cohering arrangement applied to his ear, to see over what distances he could get the signals. He succeeded in obtaining what was actually wireless telegraphy but his ideas about the phenomena were all wrong, because he thought it was a case of electrical conduction through the air. This, of course, was before the date of Hertz's discovery of the electro-magnetic waves called by his name —waves, the existence of which had been predicted by Clerk Maxwell. After perusing Hughes's notebooks it occurred to me that at some time or other he must have possessed a quantity of apparatus, so I enquired as to where these notebooks had been found. I was shown a fearful mass of rubbish in a pantechnicon off the Tottenham Court Road. There were two rooms full of old clothes, old boots and umbrellas, and masses of books and old newspapers. I went to Colonel Lyons, the Director of the South Kensington Science Museum, and he undertook to look through all this, provided if anything of interest was found it was to go to the Science Museum. As a result, a number of Hughes's original microphones and various forms of telephone receivers evidently made with his own hands, and the apparatus with which he had conducted experiments in wireless telegraphy, all in accordance with, and all readily recognised from the sketches in his notebooks, were discovered, and have now been placed in the Science Museum, where they have formed a most interesting exhibit.

It was from the late Sir William Crookes that I had heard of Hughes's wireless experiments, Sir William Crookes having been shown them in confidence by Hughes

shortly after the experiments were first made.

Sir William Crookes was a great chemist, and of him, Lord Kelvin once said that he had never known any man start as many scientific hares, meaning that Crookes had originated a great many new ideas in science which others had advantageously pursued. As is well known, he was an early believer and investigator in spiritualism, so much so, that, whereas when he was knighted and he had taken as his motto in connexion with his coat of arms the medieval proverb "Ubi Crux ibi Lux," this being a pun on his own name, some wit at one of the Red Lion dinners of the British Association altered the motto to, "Ubi Crookes ibi Spooks."

It was Sir William Crookes's investigations into the phenomena of electric discharge in high vacua, and his investigations into what he called radiant matter, that formed the first beginnings that gave rise to all the modern theory concerning the atom. Crookes also wrote a remarkable article for the *Fortnightly Review* in 1892, in which he gave a wonderfully accurate forecast of what might be done in the way of wireless telegraphy by means of Hertzian waves. No doubt, in part, he had got his ideas in this from Hughes's experiments, which, as already mentioned, he had witnessed, but his forecast went a long way beyond what Hughes had done, and it must be remembered that the article was published years before Lodge or Marconi had made any of their earliest experiments.

It was with one of Crookes's cathode ray tubes that Professor Röntgen, in 1895, discovered the X-Rays that are now known by his name. When these rays were first discovered they caused an immense amount of popular curiosity, particularly their property of enabling bones in the living person to be photographed. I possessed an early photograph of this description, the subject being my own hand, which, when the subject was new, interested people very much. I remember going one night to a club which used to meet at the Grafton Galleries on Sunday evenings, and showing the photograph to the late Lord Crawford, who was a well-known scientific amateur. It was the first time he had seen one of these photographs and he was very much interested in it. He told me that the Prince of Wales (afterwards Edward VII.) would be coming to the club shortly and he would like to show him the photograph, as it would be sure to interest him. This he did, but the only remark that the Prince made on being shown this latest scientific wonder were the words, "How disgusting!"

Shortly after Röntgen's discovery of the X-Rays, one of the most curious episodes in the history of modern science took place in France. Professor Blondlot, a well-known professor of Physics at Nancy, who had done excellent work in other directions, announced that he had discovered another and new description of radiation, which he named the N-rays. With these rays, which he stated were emitted by nearly all bodies in a state of strain, he claimed that he could see in the dark, and with them he even professed to be able to produce a line spectrum. Sir William Crookes and others in this country tried to repeat Blondlot's experiments, but no one had any real success. I can well remember my own exceeding disappointment at my failure to obtain any result after prolonged and strenuous endeavours. Sir William Crookes even went out to Nancy specially to see the rays, but came back quite unconvinced as to their existence. However, a number of distinguished French men of science continued to believe in them, and the Académie des Sciences of France solemnly presented Professor Blondlot with a gold medal for his discovery.

Shortly after this Professor R. W. Wood, of the John Hopkins University, Baltimore, came on a visit to Europe and thought he would like to see these remarkable rays. I do not think the sequel has ever been published, but I have it from Professor Wood himself. He went to France and was shown the spectrum of the N-Rays produced by means of a prism. Professor Wood himself could see nothing, but the French scientists assembled at the gathering saw, or at any rate professed to see, the spectrum, and the remarkable thing was that they continued to see it even after Professor Wood, taking advantage of the complete darkness in which the experiments were being shown, had surreptitiously removed the prism out of the apparatus and put in his pocket. Nowadays one never hears of the N-Rays, and I do not think you will even find them mentioned in any modern scientific book. Probably the phenomena were due to some peculiar form of self-hypnotism. No doubt the observers were perfectly genuine, but what they saw or thought they saw was subjective and not

objective. Anyway, Professor Wood, by his perhaps rather venturesome action, gave the N-Rays their quietus.

One of the greatest inventions of modern times is the steam turbine, the advent of which has not only revolutionised the generation of electricity on a large scale, but has also revolutionised the propulsion of big ships, rendering possible for the first time such monsters of the deep as the "Mauretania" and the "Lusitania," and such huge war vessels as the "Dreadnought" and her successors. The next illustration is a photograph, taken in 1911 at my house after dinner, by electric light, of Sir Charles Parsons, the inventor of the steam turbine, with the two engineers who did more than anyone else to introduce turbine propulsion into the Navy—Sir William White, who was Chief Constructor of the Navy when, the turbine was first adopted for Torpedo Boat Destroyers and fast cruisers, and his successor as Chief Constructor, Sir Philip Watts, who designed the original Battleship, "Dreadnought," and many other large turbine driven ships of war. In addition to his eminence as a naval architect, Sir William White possessed remarkable powers of exposition both in speech and in writing. He once told me that as a youth he had been driven to take up engineering as a profession by the necessity of earning his own livelihood, but that, if he could have afforded it, he would have preferred to have embraced a literary career. Sir Charles Parsons received the Albert Medal of the Society in the year my photograph was taken, while Sir William White was Chairman of the Council of this Society in 1908-9, and Sir Philip Watts is at present one of our Councillors.

Sir Philip Watts. Sir Charles Parsons. Sir William White.

My last illustration is another photograph, taken in 1912 in my house, of Professor Silvanus Thompson, Sir William Ramsay, and Mr. A. P. Trotter. When Professor Thompson died, in 1916, I contributed to *Nature* an obituary notice which I hope did justice in some slight measure to his untiring industry and his many conspicuous qualities both of heart and head. A few days after the notice was published an old and very well known member of the Athenæum came up to me in that club and said, "That was a nice obituary notice; I hope that when my time comes you will do as much for me." An irreverent friend, to whom I told this said, "You should have replied, 'Well if you want that you had better hurry up, because I am not feeling very well myself'."

Another little story occurs to me with regard to Mr. Trotter. He came one day to lunch at the Athenæum and when he joined me at the table he exclaimed, "I will never again help on anyone with his coat." On my asking why this sudden resolution, he replied, "A few minutes ago I saw an old gentleman in the hall struggling with his coat, so I helped him on with it, when he turned round and said so sweetly, 'Thank you so very much, but I was trying to take it off'."

In the pages of that useful periodical, *Who's Who*, it is common to state the particular recreation to which the various persons of whom particulars are given are addicted. If you look up Mr. A. P. Trotter you will find that he was for many years

Prof. Silvanus Thompson. Sir William Ramsay, Mr. A. P. Trotter,

adviser on electrical matters to the Board of Trade, and that his recreation is now "remembering that he is no longer a Government official."

Thus ends my first experiment in personal biography. I hope that at any rate it has sounded no jarring note.

[A complete list of the photographic portraits, mostly taken by Mr. Swinton himself, that were shown in the lantern at the reading of this paper is as follows :—

Professor Huxley, Lord Armstrong, Sir Andrew Noble, Professor Osborne Reynolds, Captain Casella, Lord Kelvin, Sir Frederick Bramwell, Sir G. Baden-Powell, Sir Frederick Abel, Sir William Abney, Sir Philip Watts, Sir Charles Parsons, Sir William White, Professor Silvanus Thompson, Sir William Ramsay, A. P. Trotter, Professor David Hughes, Sir William Crookes, Sir William Preece, Sir James Dewar, Alexander Graham Bell, Thomas Alva Edison, Sir Joseph Swan, Dr. Anderson, Lord Rayleigh, Sir J. J. Thomson, W. Duddell, Professor Vernon Boys, Arnulph Mallock, Professor R. W. Wood, Sir Alfred Ewing, Sir Dugald Clerk, Sir Oliver Lodge, Senator Marconi, Professor J. A. Fleming, V. Poulson, Professor Pedersen, General Ferrié, George Westinghouse, Colonel Crompton, Professor John Perry, General Sir Ernest Swinton, the Archbishop of Canterbury, Sir William Bragg, Sir Joseph Petavel, Sir Joseph Larmor, J. H. Jeans, Sir Richard Glazebrook, Major A. P. MacMahon, Professor A. A. Michelson, Sir Henry Trueman Wood.]

DISCUSSION.

Dr. W. Rushton Parker said that, as a medical man, he was interested in the lecturer's remarks about Lord Armstrong having suffered from heart disease as a young man, and yet living to the age of 90. A very eminent physician once said in the speaker's presence that when he was assistant physician at one of the leading hospitals, the secretary of the institution came to him one day and was sounded by him and told that he had heart disease. The secretary told his committee of the trouble, and in those days it was thought that if a man had heart disease his days were numbered. Therefore, the committee of the hospital decided to pension him off with a couple of hundred pounds a year, and he lived for 40 years longer. It had occurred to the speaker that frequently too much attention was paid to heart troubles in connexion with longevity. On one occasion he wanted to insure his life, and he had to send in a statement of all the doctors whom he had consulted during the past few years. Having during that period suffered from a disability which was difficult of diagnosis, he had consulted no fewer than 14 eminent medical men within a few months, and with this record in front of them the company would not insure him at any price. But that was 40 years ago and he was now over 70 years of age.

Mr. William Coldstream, I.C.S., retd., said that the name of Mr. Graham Bell had been mentioned as the inventor of the telephone. It was also mentioned that he was a teacher of elocution. The speaker was a young man in Edinburgh about 65 years ago, and took lessons in elocution from the

father of Mr. Graham Bell, who was an able teacher.

Mr. William M. Mordey, President, Institution of Electrical Engineers, said that he was able to recall Professor Hughes very well, and particularly his modesty about his work on wireless telegraphy. He showed his experiments to a number of very eminent mathematical physicists and they were puzzled, having no explanation to offer. Years afterwards, when Marconi was in the middle of his great work, the Council of the Institution of Electrical Engineers, knowing as they did of this work done by Professor Hughes, thought it would be a great thing if they could get him to contribute to their Journal some account of his early investigations. The Council deputed Professor Silvanus Thompson and himself to go and see Hughes, and ask him to allow an account of his actual experiments to be published. He discussed the matter for some time, and finally said, "No this young man Marconi is coming over here, he is going ahead, and I am not going to get up and say 'I did it.'"

Mr. R. A-Ababrelton said that the father of Alexander Graham Bell, whose name was Alexander Melville Bell, in addition to being an elocutionist, invented a system of shorthand, which was the first system of shorthand ever published in "Cassell's Popular Educator." The speaker at that time was very anxious to become a reporter and learned that system, but later had to abandon it. He was one of the few people now living who was intimately associated with Sir Isaac Pitman, and he founded the Phonetic Shorthand Writers' Association in 1872, a body which was now called the Incorporated Phonographic Society. He also wished to ask the lecturer a question with regard to the X-ray photograph of the hand, which was said to be the hand of the late Lord Salisbury. He had an impression that that photograph, or a similar one of Lord Salisbury was taken by his son, Lord Robert Cecil, now Lord Cecil, because at the time it was done, he (the speaker), happened to be Private Secretary to the present Lord Salisbury, and he knew that Lord Robert Cecil was very much interested in the taking of these photographs of hands.

Mr. Campbell Swinton said that as a matter of fact he happened to meet Lord Selborne, Lord Salisbury's son-in-law, at a time when everybody was interested in bicycling. The speaker had a very peculiar bicycle which Lord Selborne desired to see, and having looked over the bicycle, he showed him the bones of his hand. A few days later he was told that Lord Salisbury would like to come and see the bones of his hand himself. Lord Salisbury came accordingly, and a day or two afterwards Lady Salisbury also came. He heard afterwards that Lord Salisbury himself had bought an X-ray apparatus for use at Hatfield. But the photograph he had shown of Lord Salisbury's hand that evening was from the speaker's own negative.

Mr. Rollo Appleyard, O.B.E., M.Inst. C.E., said that he would tell them a story relating to Lord Kelvin. Professor Lorentz, who came over from the Continent last year, had remarked, speaking of Lord Kelvin, that Lady Kelvin must have taken great care of him, because at a lecture at the Royal Institution when Sir James Dewar passed round a vessel of liquid air, Lorentz observed that when it was handed to Lord Kelvin, Lady Kelvin caught her husband hurriedly by the arm and whispered audibly, "Don't drink it, William." He had one other story, relating to Sir Frederick Bramwell, a very remarkable man, He had many fine characteristics, and he did everything in the grand manner. He had few enemies, and a great many friends. On one occasion Sir William Preece was taking the chair at a meeting of the Society of Arts (*vide Journal* Nov. 22, 1901, p. 22), when it fell to Sir Frederick Bramwell to propose a vote of thanks. There had been a discussion on high speed railway travel, and Sir William Preece had been remarking that he would not go down to his grave happy until he had travelled at the rate of 150 miles an hour. Sir Frederick Bramwell said that if the Chairman would fall down a coalmine 784 feet deep he would, by the time he had reached the bottom, have attained a velocity of 150 miles an hour, and would certainly go to his grave.

Sir Archibald Denny, Bt., said that a good many years ago he was honoured by being made President of the Institution of Junior Engineers, then a very active Society. It was the greater honour for him because the Senior Vice-President was Lord Kelvin. Lord Kelvin sat next to him at the dinner of the Institution, and was such an exceedingly modest man that in talking to him one forgot his immense ability and reputation. Without thinking about it, therefore, the speaker began a sort of lecture on electricity, and suddenly he realised to whom he was talking, and said, "I beg your pardon, it is I who ought to listen to you, not you to me." "My dear Sir," said Kelvin, "you are quite wrong. Pray go on, go on! that is how I learn things."

The Chairman (Sir Herbert Jackson) said it was a particular pleasure to him to propose a vote of thanks to Mr. Campbell Swinton. He was sure that everyone must have had a very enjoyable evening in listening to Mr. Campbell Swinton's lecture given in so pleasing and interesting a manner. It was a privilege to have had the opportunity of seeing such a number of photographs, nearly all of which had been taken by Mr. Campbell Swinton himself. Mr. Campbell Swinton had always been so thorough in the photographic work he had done; from the first exposure of the plate to the final production of the re-touched negative and the excellent prints, everything had been done by his own hands. He had had this evening time to give them only a proportion of his interesting recollections of the many prominent men of science whom he had known. Not one lecture, but a

course of lectures would be needed, but they were all greatly indebted to Mr. Campbell Swinton for what it might be hoped was only an instalment, and for the great trouble he had taken to make his lecture interesting.

Mr. Saxton Noble seconded the vote of thanks to Mr. Campbell Swinton, whom he had known for more than 40 years. He had watched Mr. Swinton's progress among these men of wisdom, and had seen him get greater and greater himself. If he had been giving a similar lecture he would have been able to add one more photograph to the collection of great scientific men, namely, that of Mr. Campbell Swinton. He had recalled to their minds many interesting and remarkable men, the sad thing being that such a number of them were no longer with them.

The motion was passed unanimously, and Mr. Campbell Swinton, after acknowledging the compliment, said that for the lantern slides he was very much indebted to the work of his Secretary, Mr. A. W. Langley.

Sir Archibald Denny writes:—I should like to add to my remarks the following.

I remember, as an apprentice, hearing about the wonders of the telephone. It must have been about the year 1878, and Mr. Graham Bell's father-in-law was surely in charge by then, for the price of telephones was very high; but I discovered a small workshop in Glasgow where they made the parts and sold them for the purchaser to put together and thus the royalty was avoided.

I purchased a couple and at that time there was no microphone, so far as I knew. I rigged them up between my brother's room and my own and we carried on conversation but the sound was very feeble. I then heard of Hughes's french-nail microphone, of which I made a couple, attached batteries and had very clear and loud conversations.

On my return from London after my college course in 1883, the telephone had made very great progress and it was in the early eighties when I first met Mr. Swinton, who had invented an excellent microphone. We contracted with his company to fit up our offices and they worked admirably. But Mr. Graham Bell's father-in-law again intervened, and after a patent law case which Mr. Swinton lost, we had to deliver up the instruments.

That was the beginning of my friendship with Mr. Swinton, which has endured ever since. He and I well remember the primitive material used in the first development of incandescent electric lighting. The first ships my firm fitted, were the "Arawa" and "Tainui" in 1883-4. The wire procurable would hardly be used for bell wiring now, and all the fittings were on an equally primitive scale, bottom loop lamps, etc., etc.

But this brought me into contact with another of our brilliant young electricians, Mr. Ferranti, as those ships were fitted with two of his ribbon armature alternating current dynamos. It was fortunate they were alternating current as we used single wiring with the skin of the ship as return, and with the inferior wire electrolysis would have set in resulting probably in disastrous fires, had the current been continuous. I need say nothing about Mr. Swinton's later career; it is well known to us all, and he takes his place among "The notable Scientific Men" I have met.

TWENTY-SECOND ORDINARY MEETING.

SEVENTH TRUEMAN WOOD LECTURE.

Wednesday, May 21st, 1924.

Sir Herbert Jackson, K.B.E., F.R.S., in the chair.

The paper read was:—

THE OUTLOOK IN CHEMISTRY.

By Sir William J. Pope, K.B.E., F.R.S., LL.D., D.Sc.

One of the many useful functions of an ancient Society such as this is undoubtedly that of taking stock, from time to time, of the actual position which has been so laboriously achieved in one or other of the large divisions of pure or applied science. This, I feel sure, is a function which would appeal particularly to the gentleman whose services to science are to be perpetually recalled to fresh generations of students of science by the Trueman Wood lectures. And so, when the Council of the Royal Society of Arts did me the honour of adding my name to the distinguished list of Trueman Wood lecturers, the opportunity seemed appropriate for directing attention more particularly to one specific branch of science in which developments of fundamental importance have quite recently taken place.

I believe, and I think my belief is well founded, that the historian of the future will mark the last twenty-five years as one of the really memorable stages of scientific progress. This brief period has witnessed such a broadening in the scientific outlook on the physical sciences as was never contemplated towards the end of last century: a broadening of the scientific horizon which has forced previously dissonant sections of the scientific community to regard their individual subjects and their main objectives of research from precisely the same standpoint of knowledge and of purpose.

Some obscurity may attach to this problem and a little explanation is desirable. During

the nineteenth century the physicist was largely concerned with the determination of essential physical constants and the establishment of the primary relationship between the various forms in which energy manifests itself; it would be difficult to overestimate the intellectual beauty of the work of Thomas Young on the undulatory theory of light, of Clerk Maxwell on the properties of gases or of Kelvin on thermodynamics and the theory of electricity. During roughly the same period the chemist dealt in the main with the material changes brought about in ponderable matter by chemical reaction; Lavoisier's recognition of the elements and his law of conservation of mass, Dalton's establishment of the atomic theory, Frankland's doctrine of valency and his work on organic synthesis and the development of synthetic methods by Perkin, Baeyer, and Emil Fischer, are among the many expressions of genius directed towards purely chemical ends in this particular epoch. But whilst both Physics and Chemistry developed rapidly during the nineteenth century, they developed on what appeared to be quite divergent lines; they had but little community of method, of purpose or of outlook and the chemist was fairly sharply distinguished from the physicist in his mode of attacking a problem and his conception of the meaning of natural phenomena. To the chemist, and especially the organic chemist, the internal constitution of the molecule was the main object of enquiry, whilst the physicist, in his dealings with matter and energy, concerned himself chiefly with extra-molecular happenings; this statement is, of course, not entirely true and it became less true as time passed on, but it is sufficiently accurate as indicative of the diversity of outlook.

During the last twenty-five years this state of affairs has entirely changed; the physicist has developed methods for penetrating into the atoms of which molecules are made up and of elucidating the manner in which the primitive atoms themselves are built up; he has provided simple explanations of many remarkable chapters in chemistry which had been worked out in an almost entirely empirical manner with but little theoretical basis. To-day, Physics and Chemistry are but arbitrary sub-divisions of the great subject of Natural Philosophy; each of their students is a specialist cultivating some minute field of the whole domain but all have the same fundamental conception of the nature of the non-living part of our universe.

It is very interesting to attempt a comparison of the outlook of the chemist of thirty years ago with that of to-day; to make such a comparison involves a brief review of the appearance of the chemical universe then and now, indicating the milestones in the path of progress, and remarking on their significance.

Undoubtedly, the atomic theory enunciated by Dalton in 1803 remained for a century the corner stone of the chemical edifice; in essence, the atomic theory postulates that any chemical element is composed of inconceivably minute and similar particles called atoms and that the atoms of different elements combine in simple numerical proportions to form the ultimate characteristic units, the molecules, of chemically compound substances. It has always seemed to me that Dalton's atomic theory had, at the date of its enunciation, no sure foundation as a logical interpretation of observed facts, though it is naturally impossible to recover precisely the outlook of the chemist a century ago; but whether the atomic theory represented a logical interpretation of experimental observations or whether it expressed an inspiration of a great generalising intellect, it is clear that until a few years ago, the atomic theory remained a theory and nothing more. Ostwald, indeed, made an earnest attempt to present modern chemistry without the aid of the atomic theory and, notwithstanding the recognised utility of the theory as a piece of chemical scaffolding, few held the opinion until quite recently that Dalton's theory depicted an actual state of affairs or supposed it proven that atoms and molecules actually exist. After Dalton came Avogadro, who in 1811 stated the hypothesis that under similar conditions of temperature and pressure equal volumes of different gases contain the same number of molecules. Again no complete logical proof could be given that what was often erroneously described as Avogadro's Law represented an actual state of affairs; nevertheless, Avogadro's hypothesis still stands as the mechanism for rendering intelligible our methods for determining molecular weights.

Other great chemical monuments were raised from time to time; Prout's hypothesis stated in 1816 that the atomic weights are integral multiples of that of hydrogen and

become whole numbers if the atomic weight of hydrogen is taken as unity, and Mendeleef's periodic relationship between the atomic weights and physical and chemical properties of the elements, dating from 1869, had a profound influence on chemical thought. Prout's law was temporarily discarded, to be resuscitated a century later in a slightly modified form as perhaps the most striking exemplification of the truth of modern views of the nature of matter and energy; Mendeleef's periodic classification of the elements remained for half a century as a purely empirical justification of a rapidly increasing belief that the elementary atoms are complex structures and that all have a common origin.

With the rapid development of organic chemistry came the enunciation by Frankland of the doctrine of valency with its immediate clarification of our knowledge of the molecular constitution of organic compounds: the introduction of constitutional formulæ by Kekulé gave a directional lead to the work of the organic chemist and this mode of expressing the position relationships between the atoms composing a molecule, based upon the doctrine of valency, has furnished the theoretical network upon which the whole of the vast expansion of organic chemistry has been spread. Again, however, the doctrine of valency represented an empirical conception in the sense that it seemed impossible to give it any theoretical interpretation; at the same time, constitutional formulæ, although continually acquiring a more concrete character from stereochemical work based upon Van't Hoff and LeBel's conception of the asymmetric carbon atom, were commonly regarded as not necessarily of greater significance than expressing a geometrical relationship which was to some extent parallel with the actual state of affairs. Possibly, however, it is not sufficiently grasped by chemists that the introduction of constitutional formulæ, with all their modern consequences, such as the recognition of the existence of definite groups or radicles as component parts of the molecule, constituted an entire revolution in chemical thought. I have myself discussed modern organic chemistry with veterans of before Frankland's day and have been struck by their distrust of the idea that individual atoms of the component elements and specific groupings of those atoms exist as such in the complex molecule; the early conception seems clearly to have been that when two dissimilar atoms enter into combination each loses its identity and becomes, as it were, fused into the other. To our predecessors with such an understanding of chemical combination, the attribution of concrete signification to constitutional formulæ must have been peculiarly difficult.

A multitude of other steps in the development of the chemists' conception of his universe, many of them of importance, might be noted but all are of the same category as the foregoing. The gradually extending chemical outlook of the last century resulted from the exercise of great experimental skill in the collection of observational facts and in the logical generalisation from those facts which yielded the theoretical groundwork of modern chemistry: a wonderfully supple theoretical network was thus built up but it was a network which, in the end, was regarded merely as theory and not as necessarily presenting any real picture of what really exists as causative of the experimental results. This mode of conception has become obsolete during the present century; the atom and the molecule are now known to be realities and much has indeed been disclosed concerning the way in which the elementary atoms themselves are built up. It is interesting to review the manner in which the new outlook has been gained before considering how it affects modern chemistry.

The first step towards a proof of the existence of Daltonian atoms and molecules as concrete entities obviously consists in devising methods for determining some constant relating to their absolute sizes, to the number present in a definite weight of a material or to the mass of an individual atom or molecule; such quantities as these are intimately related and it is convenient, in tracing the development of the subject, to confine attention to but one of them. We may choose for this purpose the Avogadro constant, N, which represents the number of molecules contained in the molecular weight in grams of any species of matter. The mathematical development of the kinetic theory of gases by Clerk Maxwell, Clausius and van der Waals led to a method, based in part on measurements of the viscosity coefficients of gases, by which the Avogadro constant could be calculated; from measurements made on argon, the value $N = 6.2 \times 10^{23}$ was deduced.

Naturally the calculation of this quantity provides no proof of the existence of atoms or molecules because it is based upon the assumption that they do exist; the point which is of importance, however, is that many quite dissimilar methods for arriving at a value for the Avogadro constant are now available and that all lead to values which are identical within the limits of experimental error.

Thus, the botanist Robert Brown noted in 1827 that very finely divided particles suspended in a liquid appear on microscopic examination to be in a state of perpetual agitation and some sixty years later it became admitted that this incessant movement is due to the bombardment of the tiny solid particles by the swiftly moving molecules of the liquid medium itself. If this is the case, the solid particles suspended in a liquid should distribute themselves vertically according to the same law as governs the pressure of the atmosphere at various altitudes; very careful series of observations were made by Perrin of the concentration of uniform particles of gamboge at different altitudes in a thin layer of liquid and it was shown that, interpreting these data as representing an equilibrium condition between the dispersive tendency of the bombardment and the sedimenting effect of gravity upon the particles, a method for calculating the Avogadro constant was obtained. Perrin thus calculated the value $N = 6.83 \times 10^{23}$, which, considering the difficulties of the experimental work, may be regarded as identical with the value calculated from the viscosity of argon. The remarkable nature of this correspondence will be realised when it is noted that a parallel is being drawn between the weight of a gram-molecule of such a gas as hydrogen, namely, two grams, and that of the gram-molecule equivalent of the relatively enormous gamboge particles, which is of the order of 100,000 tons; also that an atmosphere of hydrogen round the earth would have its density diminished to one-half by the action of gravity at an altitude of about 80 kilometres whilst a similar diminution to one-half density occurs at a height of 0.02 to 0.03 millimetre in the suspensions of gamboge.

Again, the late Lord Rayleigh pointed out that the diffusion of light by a gas is due to the gaseous molecules acting as diffracting particles; by an argument which need not now be discussed he traced the blue colour of the sky to this effect and gave a method for calculating the Avogadro constant. This method, applied with modern refinements, has yielded the value $N = 6.54 \times 10^{23}$, again sensibly identical with those furnished by the previously entirely distinct methods.

By far the widest expansion in modern knowledge of the constitution of matter and indeed also of energy is that which has resulted from the study of radio-activity. Apart from the pioneer work on radiant matter by Crookes, the discovery of radio-activity in 1896 by Becquerel and its association shortly afterwards with radium by Madame Curie mark the opening of a fresh chapter in the development of science; so striking has been the broadening of the chemical outlook under the influence of the rapid advance in the study of radio-activity that it may be useful to note a few points of special importance. The most fundamental of these is perhaps the identification by Sir J. J. Thomson of the β-particle as the particle or unit of negative electricity and the demonstration that the α-particle, thrown out during the first stage of the atomic degradation of the radium atom, is the atom of helium carrying one unit charge of positive electricity. Following this as clearing up our ideas on fundamental chemical theory is possibly Rutherford's conception of the structure of the chemical atom; in this it is conceived that the atom consists of a nucleus, minute in comparison with the total volume occupied by the atom, which contains all the particles of positive electricity and, in the case of all the elements but hydrogen, a definite number of particles of negative electricity; the nucleus carries a positive charge equal to the difference between the number of positive particles and the smaller number of negative electrons composing the nucleus. The positively charged nucleus is in electrical equilibrium with the much larger external atomic domain by reason of the presence in the latter of negative particles or electrons equal in number to the nuclear charge. Since the property of mass is chiefly associated with the positive particle of electricity, the electron having a mass only about 1/1800th. as great, the atomic weight of an element becomes very nearly the number of positive particles contained in the nucleus; the atomic weights should thus be practically whole numbers, multiples of the unit atomic weight of the lightest element, hydrogen,

in accordance with Prout's hypothesis of 1816. Further, one of the most important characteristics of an element should be the positive charge on the atomic nucleus, or the number of electrons in the external atomic domain; this is the atomic number which was first defined by Moseley, who showed the simple relation which exists between this constant and the spectrum of the light evolved by an element when bombarded by β-particles. As connecting this strange new development of science with earlier knowledge it may be noted that the most accurate method for determining the Avogadro constant depends upon the measurement of the charge carried by the electron of β-particle; Millikan thus determined the value for N as 6.062×10^{23}, a number approximately identical with those previously quoted.

It would be impossible in the limited time now available to submit any adequate picture of the far-reaching deductions from recent work on radioactivity; one or two points may, however, be emphasised. Moseley's work on atomic numbers shows that 92 elements should exist and 87 of these are now known, five being left to be discovered; it indicates that the atomic weights of all the elements should be whole numbers. Rutherford showed that the atomic nucleus, which gives the atomic weight as the number of units of positive electricity included within it, is composed of ponderable positive particles and practically non-ponderable negative particles of electricity, the difference being the atomic number of Moseley; it appears, however, that the atomic nucleus of any particular element can preserve its identity, from the purely chemical point of view, if containing one or more positive and the same number of negative units of electricity less.

The positive charge, the Moseley atomic number, would be thus left unaltered and consequently the identity of the element for purposes of chemical change, should remain unchanged. In accordance with this Aston has found in a large number of cases that the chemical elements are mixtures of atoms of different nuclear composition, although identical as regards the number of negative electrons which compose the outer or chemically active atomic domain. Elements which differ to the extent just indicated in nuclear composition, but which are identical in the number of electrons present in the external domain, have been termed isotopes; it is now known that the atomic weight of each variety of any element appears as a whole number when referred to a particular unit. For a reason which is not yet elucidated, but which is certainly of significance in connexion with our knowledge of the relation between matter and energy, the unit value for the atomic weight of hydrogen has to be selected as 1.008; this unit chosen, the atomic weights of the isotopes of all the elements appear as whole numbers. The empirical deduction of Prout of a century earlier has thus been completely justified. Again, the purely empirical deduction by Mendeleef of the so-called periodic classification of the elements, which has exercised enormous influence in the development of inorganic chemistry, has found complete theoretical justification in the arrangement of the elements in sets of eight in accordance with the system of atomic numbers introduced by Moseley. The deductions drawn by Lavoisier about 1775 which indicated the existence of chemical elements and stated the law of conservation of matter both find theoretical justification in modern conclusions; each chemical element is characterised by the Moseley atomic number and the law of conservation of matter stands subject to the slight adjustment involved in the attribution of an atomic weight of 1·008 to hydrogen. Lastly the atomic theory of Dalton has passed from the stage of being merely a useful hypothesis to that of stating an actual condition of affairs; it is safe to assert that never again in the history of science will the existence of atoms of the elements be seriously challenged.

So far we are on undebatable ground but much more still disputed territory is in sight which will undoubtedly be secured in the very near future. The nature of chemical combination has been long in dispute; the Frankland doctrine of valency has been very fertile as leading to a classification of types of reaction and to a very perfect system of indexing the composition and constitution of chemical compounds. It seems likely that the Rutherford conception of atomic structure, interpreted quantitatively by Bohr and his co-workers, and adapted to chemical mechanisms by men of the Langmuir and Millikan school, will ultimately provide a satisfactory solution of many of the baffling problems now presented by the question of atomic valency.

Yet another remarkable chapter has been recently opened in connexion with the

confirmation by contemporary physicists of the singular accuracy of the manner in which chemists long before had interpreted the observed facts relating to molecular constitution. Frankland's doctrine of valency enabled Kekulé about 1858 to develop the theory of the molecular constitution of chemical compounds and later generations of chemists have brought to a great state of perfection the methods for ascertaining the manner in which the component atoms of an organic molecule are joined together. The precision of the synthetic methods of organic chemistry and the striking facts of stereochemistry made it certain that the so-called structural formulæ run closely parallel to the actual arrangement of atoms in the chemical molecule; at the same time, no independent or more direct confirmation of the substantial correctness of constitutional formulæ was until quite recently forthcoming.

The purely geometrical investigations of Bravais, extended and completed by Sohncke, Schönflies and Barlow, have long since shown that all properties of crystals are consonant with the supposition that crystal structures consist of a regular repetition in space of the molecular units, and consequently also of the atoms which compose the molecule; any particular plane section of a crystal is thus to be regarded as having a definite reticulated pattern formed by the geometrically regular repetition of component atoms in the plane. It has also been long known that light is diffracted in accordance with well-understood laws from gratings ruled with a large number, say one hundred thousand to the inch, of fine lines. The reticulated pattern of a crystal surface is, of course, far more minute than corresponds to the dimensions just stated and X-rays are of wave-lengths of the order of one-tenthousandth of those of visible light. It thus occurred to Laue in 1912 that X-rays should be diffracted from a reticulated crystal surface in the same way that visible light is diffracted by a grating; he showed this to be the case and shortly afterwards Bragg founded upon this observation a method for determining the atomic spacings in a crystal by observation of the manner in which X-rays are diffracted from the crystal. Debye and Scherrer showed a little later that massive crystals are unnecessary for the application of the Bragg method but that finely powdered crystalline material can also be used and, in fact, the study of X-ray diffraction from particles of colloidal gold in aqueous suspension has proved that the colloidal particles of this element are crystalline.

The Bragg method has been intensively applied during the last few years and has demonstrated that the constitutional formulæ deduced in an entirely different fashion by the chemist are substantially correct representations of the actual manner in which the atoms are arranged in the chemical molecule.

This necessarily very abbreviated summary of the most important directions of recent progress in physics in so far as they influence chemistry will suffice to prove a quite simple thesis. Whilst the chemist at the end of last century had laid certain theoretical foundations to his science, more particularly those connected with the atomic theory, the doctrine of valency, the Mendeleef classification of the elements, and the vast network of organic chemistry which culminates in the determination of molecular constitution, all these achievements remained as theories or even in part as mere hypotheses until the sudden development of physics during the last twenty years or so transformed them into actual statements of fact. The history of science has never before had to record so dramatic and far-reaching a broadening of the horizon as that which has so recently unified chemistry and physics.

It is doubtful whether the importance of the unifying process which has been carried out so rapidly has been sufficiently realised by the majority of those interested in physico-chemical science, and attention may be directed to one aspect of the question which appears to be relevant.

Whilst the present generation of students is acquiring an outlook very different from that prevalent a few decades ago, our general organisation of teaching methods remains unchanged. The student commences his training in natural philosophy by attending separate courses in inorganic and organic chemistry and in general physics, including heat, electricity and magnetism. But the reason for this early differentiation has now entirely vanished, if indeed, it ever really existed; all these subjects have the same basis, namely the electronic constitution of matter and energy, and it would seem more rational for the student of natural philosophy to commence his training by a general course for the purpose of elucidating the manner in which

all these specialised sections of the one large subject fit into the one great scheme. Students have frequently asked me how to reconcile the tenacity with which a complex molecule of an organic compound retains the perfectly definite arrangement of its component atoms with the view that an atom itself is but a minute nucleus surrounded by a large planetary system of particles of negative electricity in rapid gyration; there is indeed a striking contrast between the rigidity of molecular structure evinced by organic compounds and the apparently flimsy nature of the rotating sub-atomic units from which the whole wonderful edifice is built up. Our teaching methods require considerable adjustment to make them fit the exigencies of the modern scientific outlook.

Probably I have said sufficient to make it clear that the outlook in chemistry is far broader than it was twenty-five years ago; we understand now the meaning of much that had been painfully deduced by generations of careful observers of experimental facts. We may now proceed to enquire what we see in front of us as the result of the wider outlook.

All enquiring minds in science are accustomed to peer into the future in an attempt to discern the directions in which progress is possible; hundreds of imaginative writers have tried to foretell the effects upon human life which will accrue from coming advances in science. In this connexion I desire to submit one ruling principle, a principle which is admirably exemplified by the directions of progress during the present century and which appears to be as yet but ill recognised. The principle is that all scientific prophesy which goes outside what will obviously and logically result from the normal and unsensational development of the existing scientific position is necessarily false. No one in 1900 ever conceived anything so sublime and yet so fantastic as the achievements of the past quarter of a century.

Fears are often expressed that humanity is being impoverished and that posterity will be embarrassed by the rapidity with which our coal and petroleum resources are being consumed; but it is reasonable to presume that long before these potential supplies of energy have disappeared their applications will have become obsolete. Whilst every motive exists for employing our present sources of energy with the maximum efficiency we may safely leave posterity to look after itself with the aid of the scientific heritage with which it will be endowed. The desire to leave coal and petroleum for our successors to consume shows benevolence but appears no more rational than the action of our ancestors in planting England with oaks after the Napoleonic wars so that we might not lack material for the building of battle-ships.

But whilst we cannot see far into the scientific future we can safely foretell certain immediate consequences of the position which chemical and physical science has so lately attained; we are confident that the period, 1925-1950, will be as prolific of discoveries previously unimagined as was the period 1900-1924, and it is futile even to speculate concerning the entirely novel conceptions and discoveries which the next quarter of a century will bring in natural philosophy.

It may be taken for granted that the Bragg method for determining crystal structure, which is still in its infancy and not so far capable of dealing directly with the lighter elements, will provide a means for locating accurately all the atoms present in any molecular complex, either inorganic or organic. This must lead to a great development in our knowledge of chemical structure and should enable the relations between chemical constitution and physical properties, many of which have merely been studied empirically up to the present, to be discerned and stated with precision. Thus, it may be expected that the exact relation between the molecular configuration of an optically active substance and its molecular rotatory power will be ascertained.

Our present knowledge of atomic constitution, with its inevitable developments and its applications to the elucidation of valency, and the elaboration of purely physical methods for determining molecular constitution, may be expected to throw light on an almost infinite number of points of detail in organic chemistry which are still obscure. We may expect to learn the cause of the great stability of the benzene ring, the basic principle underlying the tautomerism exhibited by ethyl acetoacetate and its analogues, the origin of colour in the quinones and why copper of atomic number 29 refuses to form organo-metallic compounds whilst its followers in the series of the elements, namely, zinc, gallium, germanium, arsenic, selenium and bromine,

of atomic numbers 30 to 35, all combine with methyl radicles. A quantitative explanation of the energy changes which accompany chemical reactions is to be anticipated. An exposure of the mechanism attending chemical changes in general and of catalytic reactions in particular should be forthcoming; the importance of this latter in connexion with the chemical operations performed by living matter, as bearing upon the utilisation of energy at low potentials for synthetic purposes, can hardly be exaggerated.

A myriad of other obscure questions, which the chemist has already carried nearly as far as his classical experimental methods will permit but which are obviously open to further elucidation in the light of modern methods, will suggest themselves to the intelligent student of chemistry. A danger, indeed, exists that we may encroach on the domain of the imaginative writer of fiction by speculating on the new chemistry which is foreshadowed by Rutherford's transmutation of the elements by the α-particle bombardment of the atomic nuclei and on the complications which will ensue when the several isotopes of many of the elements are available in quantity; although it is often stated that the isotopic varieties of an element will never be isolated in such quantities as are necessary for chemical work yet it is difficult to believe that this state of affairs will long persist. It may be taken for granted that in due course the isotopic chlorines of atomic weights, 35 and 37, will be available in quantity.

Up to the present, I have only discussed the change in the chemical outlook which has resulted from the superb achievements of modern physics, but another and very dissimilar factor has been simultaneously operative. Although the theoretical basis of modern chemistry is of a comparatively simple character, the mass of exact and detailed experimental material laboriously collected and recorded during the last century has made every chemist a specialist; each has ultimately been forced to settle down as a cultivator of one minute patch of the vast chemical domain. A tendency towards individualism has thus been fostered. If we look around, however, we see that a tendency in a contrary direction has become operative, namely, towards combined action for the purpose of producing a definite mass effect. The coal-tar colour industry furnishes an illuminating example of this effect; for many years past a large community of most competent chemical investigators have devoted themselves to the exploitation of the subject of dyestuffs in conjunction with similar bodies of industrial and commercial experts. It cannot be denied that this co-operative effort has produced remarkable results; not only has it, in a comparatively brief span of years, succeeded in dominating one of the oldest and most conservative industries in the world, but it has extended its influence in many other directions. The coal-tar colour industry has, in fact, made itself essential in the production of materials necessary to many other industries, such as those of pharmacy and photography; whilst avowedly commercial in its aims, it has contributed much to the purely scientific development of organic chemistry.

Something very similar has taken place in the electrical industries. Certain of the great research laboratories which form part of a number of electrical firms have made most valuable contributions to the science of pure physics; they can afford a huge expenditure of money for scientific equipment and can attract the assistance of real leaders in contemporary science.

In chemistry itself the advantages of collective effort towards the extension of industrial efficiency is not confined to the coal-tar colour industry; it is seen in the gas industry and in the novel institution, fostered by experience gained during the war, of research establishments each devoted to the development of some specific large branch of manufacturing industry. But if chemical science is to carry its full responsibility in connexion with the amelioration of the conditions of life, far more must be done to ensure efficient team work in developing the applications of chemistry to human interests.

A few examples will illustrate this. The spirochaete of syphilis is susceptible to treatment by certain organic arsenic compounds; knowing this, Ehrlich conceived the idea of studying the therapeutic action of a long series of such compounds for the purpose of selecting the most suitable for the treatment of this disease. He ultimately decided that one particular substance, the so-called 606, was the most satisfactory curative agent from amongst the many which passed through his hands. Since Ehrlich's day other organic arsenic

compounds have been introduced for the treatment of this particular disease but all present certain disadvantages and possess certain limitations in efficiency. No thinking person can doubt that if 10,000 compounds, all variously toxic to the spirochaete had been studied, one immeasurably superior to all the others as a curative agent would have been found; this could have been easily done by team-work, and such a discovery would have repaid thousands of fold the original outlay on experimental work. A similar tale has to be told concerning sleeping sickness; Bayer 205 seems to be useful but something much better would certainly have resulted from the examination of some scores of thousands of chemical substances. No such success can be claimed in connexion with the foot and mouth disease, which has cost the country many millions of pounds during the last year, because team action has not been enlisted and consequently absolutely nothing is available for the treatment of this particular malady. A pressing need exists in this country for an organisation with the duty of drawing up schemes for the preparation of long series of related compounds of possible therapeutic value, making the substances and subjecting them to pharmacological investigation.

Let us take another instance. The common and the noble metals have been for centuries the materials of staple industries in many parts of the world; no one metal finds industrial applications in a state of purity but all are used as alloys with other metals. This being the case, and since none of the alloys in general use approaches perfection, it would have been anticipated that by this time we should have been in possession of an elaborate scheme of experimental data which would provide exact information concerning the properties of every possible admixture of one particular metal with one or several other elements; the scheme would, of course, be a very complicated one, but not nearly so complicated nor as difficult and costly to work out as our present system of organic chemistry.

In spite of much pioneer work by Sorby, Heycock and Neville and many others, no such scheme has been evolved; the National Physical Laboratory is now just initiating an experimental investigation for the purpose of studying the alloys of pure iron and chromium and this if successful will be the first occasion on which the systematic study of alloys of pure iron with another pure metal has been undertaken.

Much more might be said on the need for a broader outlook on the applications of chemistry to other sciences and to the arts and on the necessity for the detailed working out of large and comprehensive plans, involving much experimental work of a rather routine or repetitive nature, so as to provide the vast amount of precise data always essential to any application of chemistry to technical ends. Many cases in which valuable results would be thus achieved will occur to anyone familiar with chemical science and acquainted with its bearings upon other branches of knowledge.

DISCUSSION.

The Chairman (Sir Herbert Jackson) said that the audience would agree with him that Sir William Pope had delivered a lecture of the first order. He had started by saying that this Society of long foundation was a proper place in which to take stock of the state of our knowledge. The speaker thought that when the lecture came to be printed, and they had an opportunity of reading it, they would be indeed grateful to Sir William Pope for what was an extremely valuable stocktaking survey. He had put shortly—taking less than an hour to do it— the recent and present position in a most illuminating and suggestive way. Naturally when he came to deal with earlier views on crystal structure, in discussing the many suggestions which to some extent foreshadowed the results that had been obtained with X-rays, he omitted his own name; but the learned societies before whom he brought his work knew what Sir William Pope had done on that subject. Then he had taken them through the wonderful and inspiring part of the story, the application of shorter and shorter wave lengths of radiation to the study of the structure of the atom. When they thought of what had been done with the microscope, with the proper interpretation of the scattering of light, with the influence of short wave-lengths in the ultra-violet portion of the spectrum, and then with X-rays, they would realise what a wonderful part light had played in the whole subject, and now that they were beginning to see the work which had been done on the quantum theory of light they had every reason to believe that there would be a still larger part for light to play and more wonderful deductions to be drawn from its action. He often wondered whether the deductions of the old-time workers on the subject of light were quite so empirical as some supposed. Every day that brought further discoveries made him feel more and more respect and admiration for those who went before them and the work they did. Great men of science in different ages had thought alike, and they had only to take recent ideas of light to realise that with something added to

Newton's corpuscular theory they would get near to the theory of the present time which had been dealt with in recent publications. He did not desire to enlarge on Sir William Pope's lecture, and the best thing he could do at the moment was to interpret their feeling of gratitude to the lecturer. But he would like to point out what a very large field the lecturer had taken. Towards the end he spoke at some length on education and industry, although in the early part of his lecture he had dealt with theoretical matters. This would be a truly valuable addition to the Trueman Wood Lectures.

MR. A. A. CAMPBELL SWINTON, F.R.S., in supporting the vote of thanks proposed from the Chair, said that they had all listened to Sir William Pope with extraordinary interest. The speaker did not pretend to be a chemist, but no one could have listened to the lecture without getting a wonderful idea of the progress that had been made in chemical discovery during the last twenty-five years. Chemistry had always appeared to him —knowing very little about it— as a most difficult and complex subject. Perhaps it was becoming more simplified now that the real reasons for the different combinations and the atomic construction were being better understood. It was becoming more a matter of arrangement of particles which anybody could follow, and less a juggling with figures which the chemist might understand but which were Greek to the layman. He did not wish to enlarge on the matter, he would merely endorse what the Chairman had said.

The vote of thanks was accorded unanimously.

SIR WILLIAM POPE, in expressing his acknowledgments, said that he felt with regard to the Chairman that he was treating him with the partiality with which an old friend was generally treated. He had been associated with Sir Herbert Jackson for very many years, and he could quite understand that he expressed himself in a particularly friendly way when he came to addressing them on a resolution of this kind. It had been a great pleasure to him to come and talk about these things, and he hoped that some of the students would have found matter of interest in what he he had said.

LA VIE INDUSTRIELLE EN FRANCE.

LA FABRICATION DE L'AMMONIAQUE SYNTHÉTIQUE PAR LE PROCÉDÉ HABER, A LA POUDRERIE NATIONALE DE TOULOUSE.

Une partie de la Poudrerie de Toulouse, immense usine créée pendant la guerre et inexploitée depuis 1919, doit être bientôt affectée à la fabrication de l'ammoniaque synthétique, par le procédé Haber. Cette organisation, qui résulte d'une loi votée en avril dernier après de longs débats au Parlement, confie l'exploitation de l'usine à un "Office National de l'Azote."

Les besoins de la France en engrais azotés sont énormes; on les estime à près de 2 millions de tonnes d'azote, ou 70 kilogr. par hectare cultivé. Or, les terres n'en reçoivent guère que 45 kilogr. par hectare, et c'est une des principales raisons de la médiocre récolte française de blé (15 quintaux à l'hectare, en bonnes années), alors que la Belgique obtient jusqu'a 25 quintaux.

Les procédés de préparation des engrais azotés synthétiques sont nombreux; quatre seulement sont utilisés en France, dont trois par l'industrie privée: le système français Claude, le système italien Casale, et la cyanamide calcique, fabriquée dans cinq grandes usines hydro-électriques des Alpes et des Pyrénées. Le dernier est le procédé Haber, originairement propriété de la Badische Anilin und Sodafabrik, d' Oppau (Rhénanie), avec laquelle l'Etat français a conclu un contrat lui garantissant la bonne marche de sa fabrication.

Le projet primitif, de confier l'industrie privée l'exploitation de l'usine de Toulouse, n'a pas eu de succès, et la loi a prévu pour cela un établissement public placé sous l'autorité du Ministère des Finances, et doué de l'autonomie financière; il s'occupera de fabriquer et de vendre les engrais et produits azotés ou leurs accessoires. En fait, le Conseil d'Administration de cet Office de l'Azote sera presque entièrement composé de fonctionnaires supérieurs, et le contrôle parlementaire ne sera pratiquement assuré qu'en cas de déficit, à couvrir par des crédits fournis par l'impôt. Aussi a-t-on fait observer que cette concurrence faite par l'Etat français à l'industrie privée qui exploite d'autres procédés, est dangereuse pour celle-ci, que grèvent de nombreuses et lourdes taxes, en même temps qu'elle consacre une sorte de nouveau monopole d'Etat, au moment où les monopoles existants sont reconnus fonctionner avec un rendement très médiocre.

L'AVION BREGUET DU RAID PARIS-TOKYO.

On connaît le voyage remarquable exécuté par le Capitaine aviateur Pelletier d'Oisy et son mécanicien Besin, de Paris à Tokyo, du 24 Avril au 9 Juin. Le but principal de cette entreprise était de montrer la possibilité d'effectuer un voyage extrêmement long, à travers des climats divers, avec le même appareil monté et entretenu en état de marche par les mêmes aviateurs pendant tout le parcours.

L' expérience a été particulièrement probante, puisque les aviateurs ont été jusqu'à Shang-Hai avec le même appareil, et qu'ils auraient atteint vraisemblement Tokyo sur leur avion, sans leur accident d'atterrissage sur un terrain de polo. Ils ne purent repartir que quelques jours après, sur un avion vieux de 5 ans, avec lequel ils atteignirent enfin Tokyo. Ils avaient été de Paris à Shang-Hai en 92 heures de vol, couvrant ainsi 16,450 kilomètres (10,225 miles), soit à la vitesse de 178 km. 8 (111 miles) à l'heure. Le voyage s'était fait en 13 étapes, dont la plus longue avait été de

2,000 kilomètres (1,243 miles) faite en 11 heures. Le voyage complet jusqu'à Tokyo, représente un parcours de 20,220 kilomètres (12,564 miles).

Cette expédition montre, non seulement le courage et l'endurance des aviateurs, mais encore les bonnes qualités de l'avion qui a servi jusqu'a Shang-Hai. C'est un appareil du type de série Bréguet, biplan à deux places, de construction métallique, sauf le revêtement des ailes qui est en toile, muni d'un moteur Lorraine-Diétrich de 400 H.P. placé à l'avant. L'envergure de l'appareil est de 15 mètres (49 ft.) et sa longueur de 9 mètres (29½ ft.), la surface totale portante est de 50 mètres carrés (538 sq. ft.). Le moteur est à 12 cylindres en V, de 120 millimètres (4¾ in.) d'alésage et 170 millimètres (6 11/16 in.) de course, pesant en ordre de marche 410 kilogrammes (904 lbs.) et tournant à 1700 tours; il entraîne l'hélice directement. Deux bielles voisines attaquent le même maneton, de sorte que l'arbre vilebrequin ne comporte que quatre paliers. L'allumage double est obtenu par deux magnétos à volet tournant, donnant 4 étincelles par tour.

Les soupapes sont en acier au chrome-tungstène. Les carburateurs sont à fonctionnement automatique; ils comportent un correcteur altimétrique; leurs corps sont réchauffés, pour éviter la formation de givre. Ils sont alimentés par deux pompes volumétriques à débit automatiquement réglable, à soufflet métallique évitant tout frottement.

La mise en route peut être réalisée à partir de la place du pilote, après injection préalable d'essence au moyen d'une pompe comprimant dans les cylindres un mélange dosé d'acétylène et d'air, à travers des clapets spéciaux. Ce mélange est enflammé par une magnéto de départ à main.

La puissance du moteur correspond à environ 18 H.P. par litre de cylindrée. La consommation moyenne est d'environ 240 grammes d'essence et 20 grammes d'huile par cheval-heure.

Le poids total de l'appareil, en ordre de marche, est de 2485 kgs. (5480 lbs.), avec les deux aviateurs et tout le matériel.

L'Essai des Aciers aux Etincelles.

Pour arriver à classer, sans perte de temps, les diverses catégories d'aciers, et aussi pour les distinguer d'autres métaux ayant un aspect analogue, un procédé dont le principe était déjà connu, vient d'être repris et mis au point par M. Pitois, Ingénieur en chef des Services techniques de l'Aéronautique.

Il est basé sur l'examen méthodique des étincelles que donne l'acier (ou la fonte) soumis à un meulage sur la meule d'émeri. La forme et la coloration de ces étincelles, produites par l'arrachement de particules microscopiques de métal que l'oxydation porte aussitôt à l'incandescence, caractérisent très bien la nuance du métal soumis à l'essai.

C'est le carbone de l'acier qui brûle ainsi, et par conséquent la combustion, donc l'incandescence, est d'autant plus intense que l'acier est plus carburé. Les éléments tels que le nickel, le tungstène, etc., agissent pour atténuer l'éclat des étincelles.

Toutefois, ces variétés d'étincelles sont difficilement perceptibles à l'oeil; le procédé de M. Pitois est donc caractérisé par l'emploi d'un appareil photographique qui les enregistre et permet de les examiner, agrandies, avec tout le loisir voulu. Son dispositif comprend une boîte étanche où l'on peut remplacer l'air par de l'oxygène, et à l'intérieur de laquelle tourne une meule en émeri; l'échantillon est présenté à cette meule sous pression constante. Un appareil photographique avec objectif à grande ouverture prend des vues sur plaques extra-sensibles, et les gerbes d'étincelles y apparaissent nettement différenciées.

Par exemple, les étincelles en fuseau, en fourche, en étoile simple, en étoile multibranche, en éclatements multiples, en houppe, en épis, en fleur, en bouquet de fleurs, caractérisent successivement les aciers extra-doux, doux, doux trempants, demi-doux, fortement demi-doux, demi-durs, fortement demi-durs et extra-durs.

On remarque la distinction de la nuance douce trempante par l'apparition de l'étoile, qui marque la limite des aciers propres à la cémentation et à certaines utilisations, notamment lorsqu'il s'agit de tôles, l'emploi comme chemise à eau dans les moteurs d'avion.

De même, aux étincelles, on voit tout de suite si une fonte grise, dont la caractéristique est une gerbe rouge sombre à rares éclatements en hallebardes, a une croûte blanche, dont la caractéristique est une gerbe brillante à éclatements en fleurs de lys, et l'on évite ainsi bien des détériorations d'outils.

Enfin, pour les aciers spéciaux, M. Pitois a publié des séries de planches photographiques fixant également les caractères principaux permettant de reconnaître chaque constituant, et notamment le silicium, le nickel, le chrome, le tungstène et le manganèse.

La plupart des aciers, qui dans l'air donnent des gerbes rouges, flambent dans l'oxygène sous l'action de la meule, mais il en est qui résistent, certains partiellement, d'autres totalement. La proportion et la fréquence des éclatements blancs renseignent immédiatement sur le degré d'inoxydabilité à haute température de l'acier essayé; on a donc là un nouveau critère extrêmement précieux pour les aciers à soupapes.

L'emploi de la Chloropicrine pour étouffer les Cocons de vers à soie.

Les cocons de vers à soie doivent être étouffés pour tuer les chrysalides avant l'éclosion des papillons qui perceraient les coques et les rendraient inutilisables. En Europe, on opère l'étouffage par la chaleur, mais il faut éviter avec soin, aussi bien un excès de chaleur qui altère la soie, qu'un défaut de chauffage qui ne tue qu'une partie des chrysalides et donne lieu à des déchets importants.

Le froid artificiel est coûteux; les gaz inertes ou toxiques tels que H, Az, CO^2, SO^2, AzH^3, etc., sont insuffisants, ou altèrent la soie. Mais on

vient de reconnaître, par des essais répétés, que la chloropicrine, gaz asphyxiant employé pendant la guerre, se prête très bien à l'étouffage, et on peut prévoir que son emploi sera précieux pour les filateurs français, dont l'industrie est si importante et met en jeu des capitaux de plus en plus grands, à mesure que la soie augmente de valeur.

AGRICULTURAL AND FOREST PRODUCTS OF CUBA.

According to the Report on the Economic Conditions in Cuba by the Acting British Consul-General at Havana, the *cattle-breeding* industry of Cuba is probably the third in order of importance amongst Cuban industries, coming after the sugar and tobacco industries. The capital invested in cattle breeding is some $350,000,000.

Of the superficial area of some : 01 million acres, roughly one-third is devoted to cattle-breeding, although in a somewhat primitive way. There is no particular cultivation of pastures except in certain places, chiefly in the provinces of Camaguey, Santa Clara and Oriente (Bayamo and Manzanillo).

There are to-day some 4,500,000 head of cattle in the Island. They are of very mixed breed; Durham and Devonshire blood is visible in Camaguey and Oriente and Hereford in Santa Clara. After the War of Independence, when the industry was practically destroyed, a great number of cattle for stud purposes were imported from Jamaica. In the province of Havana where dairy farming flourishes, the breeders favour Holstein and Jersey blood.

A large number of animals are still imported for stud purposes, almost all coming from the Southern States of the United States of America, as animals from these parts acclimatise themselve more readily.

The health of cattle is good, though the feeding presents a problem, but breeders have planted large areas of guinea grass on the high lands and Parana grass on the low-lying swampy lands with ood results.

The general state of the industry is good and the prospects excellent.

Some 8,′00 acres of land are now under *henequen* cultivation, but there remains at least 1,000,000 acres suitable for this purpose. The largest company cultivating henequen and elaborating the fibre owns some 200 caballerias under cultivation, with headquarters in Matanzas.

The annual production of fibre is estimated at eight million pounds weight, and the output of rope, cordage and string is in bulk about equal to the total production of fibre; in addition to a considerable local consumption it is largely exported. This industry is capable of expansion, but it means the tyin -up of capital for about four years before results can be obtained.

Grape fruit in Cuba, and more, especially in the Isles of Pines, has been a fairly good proposition, but the in ustry has one back in the last ten years, and to-day there are only some 5,000 acres under cultivation in Cuba proper.

The approximate yearly yield in C ba is probably about 50,000 boxes, of which some 10,000 are exported to the United States of America. The London market takes about 25,000 crates per annum, but this could no doubt be increased. While the industry in Cuba proper is going back there are prospects of further developments in the Isle of Pines due to the more favourable climatic conditions.

In the Isle of Pines there are about 2,500 acres under cultivation, and some two and half million dollars are invested—entirely American and Canadian capital. New York receives some 50 per cent. of the output, Chicago 40 per cent., and other places in Canada and Europe the balance.

In 1922 a total of 217,731 crates of grape fruit was shipped from the Isle.

Timber.—About one-sixth of the area of Cuba can be termed forest land, and the best of this is situated in the provinces of Camaguey and Oriente.

The principal and most valuable Cuban woods are, in their order of importance: cedar, mahogany, and "majagua" (of the linden family). There are, however, many others, uses of which are restricted either by quality or quantity.

The approximate annual consumption of timber is about 25,000,000 feet, valued at $2,300,000. Exports are about 4,000,000 feet annually, 75 per cent. of which is mahogany, 20 per cent. cedar and the rest "majagua" and other woods. The annual value of timber exported is about $360,000. About 80 per cent. of the export is to the United States of America and 20 per cent. to Europe.

The cultivation of *coffee*, formerly a valuable Cuban industry, with headquarters in Oriente province, has been steadily decreasing for a number of years, and finds itself at present in a very grave condition, so grave indeed that about two-thirds of the producers are inclined to abandon the cultivation. The reasons underlying this state of affairs are, according to the producers, the entire lack of Government support, the high rate of interest charged on loans, viz., from 1 per cent. to 5 per cent. monthly, and the shyness of capital. Two measures which have been recommended are: (1) An educational campaign directed towards better methods of cultivation; (2) a Government loan to the Association of Coffee Producers of not less than $200,000 from which that Association can make loans to the producers of three years' duration at a rate of interest not exceeding 6 per cent. per annum.

MEETING OF THE SOCIETY.

Dominions and Colonies Section.

Thursday, July 24, at 4.30 o'clock:—M. Franck, late Colonial Minister of the Belgian Government, "Recent Developments in the Belgian Congo."

Journal of the Royal Society of Arts.

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FRIDAY, JULY 18, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICES.

NEXT WEEK.

THURSDAY, JULY 24th, at 4.30 o'clock (Dominions and Colonies Section.) M. FRANCK, late Colonial Minister of the Belgian Government, "Recent Developments in the Belgian Congo." The Hon. W. ORMSBY-GORE, M.P., will preside.

EXAMINATIONS.

The number of papers worked at the Society's Examinations this year is 67,280. This constitutes a record, and is an increase of 2,762 over the total for 1923, when the number was 64,518. For the first examination, held in April, the papers worked numbered 25,778, as against 21,288 in the corresponding examination last year. For the May-June series the papers worked numbered 41,502. For the second examination last year, the number was 43,230. In the Advanced Stage, the total for both examinations is 8,419 compared with 8,688 last year. In the Intermediate Stage the totals are 23,762 in 1924, and 23,132 in 1923. The figures for the Elementary Stage are 36,099 this year, and 32,698 last year.

The principal subjects taken and the number of papers worked in each were:—Book-keeping, 20,410; Shorthand, 13,523; Arithmetic, 7,465; Typewriting, 6,476; English, 5,691; French, 4,808; Theory and Practice of Commerce, 1,040; Commercial and Company Law, 740; Accounting, 621.

The examinations were held in most of the principal cities and towns of Great Britain and Ireland, and in nearly all cases were conducted and supervised by the Local Education Authorities.

There were 363 Centres for the April Examinations, and they were held at 345 Centres in May-June. The County of London, where the Examinations are under the control and supervision of the London County Council Education Committee, is only counted as one Centre, though it includes entries from nearly 200 Evening Institutes, Polytechnics, Proprietary Schools, etc.

PROCEEDINGS OF THE SOCIETY.

TWENTY-FIRST ORDINARY MEETING.

WEDNESDAY, MAY 14th, 1924.

MR. ERNEST POLAND, Vice-President of the London Fur Trade Association, in the chair.

THE CHAIRMAN, in introducing the lecturer, said Mr. Ingrams had for many years been associated with the celebrated Hudson Bay Company, and no one could have been selected who was better able to deal with the subject.

The paper read was:—

FURS AND THE FUR TRADE.

By F. C. INGRAMS,

President of the London Fur Trade Association.

We should not be wrong in saying that the fur trade is perhaps the oldest trade in the world, as it probably dates from the Bronze Age, when barter at least took place in articles which exceeded the personal needs of the producers. In any case, the necessity to our remote ancestors of wearing skins of animals for their first primitive garments originated at a still more distant period. The first traces of the use of skins as clothing are to be found in the Palæolithic or Early Stone Age. From deposits of this age, flint implements which were used as scrapers for preparing skins have been found. Here is one found in Essex a few months since, and here is one from the Arctic regions which I brought home two years ago. In the Neolithic or Later Stone Age, we find these implements much improved, besides needles of bone for sewing the skins together into clothing, the thread for this purpose being made from sinews.

Amongst other animals of which remains have been found belonging to this latter period are those of bear, badger, wolves, pine stone martens, foxes, otters, beavers, polecats and wildcats. In the Bronze Age skins were extensively used for garments, though traces of woollen and linen fabrics of that period have also been found.

It is uncertain, however, whether the finer sorts of furs were utilised until the barbarous Northern tribes became more civilised and a demand arose for objects of adornment.

Almost the first notices of importance of a traffic in furs are those referring to the Scythians, the inhabitants of the modern Russia, whose commerce is stated by Herodotus in the 5th century B.C. to have consisted principally of peltry, a commodity in which they had long traded.

The Greeks and Romans do not appear at first to have worn furs, even as an article of luxury, though Cæsar, and later Sallust and Tacitus, relate that the German tribes were clad in skins, which were deemed a badge of barbarism; and it was not until the 3rd century of our era that a taste for this mode of adornment began to be acquired by the Romans from their contact with the Northern people. The invasion of Italy by Gothic nations at the end of the 5th century, and the rule at Rome of a Gothic king a short time later, had the effect of further introducing amongst the Romans the custom of wearing furs, thus giving rise to the first fur trade from the North with South European civilisation.

The Black Sea trade, though of importance in earlier times, received considerable impetus after the building and dedication of Constantinople by the Emperor Constantine in 330 A.D., and amongst the articles of commerce, furs found their way to this city, which was shortly to rise to great prosperity.

A fur trade of importance was carried on from Russia by Norse and Danish traders, by way of the Baltic and North Seas in the 8th and 9th centuries. It is at the latter period that we hear of expensive furs being worn at the Court of Charlemagne and of ermine being known in England. In the 9th century the Muscovites (or Russians) were engaged in an important traffic in peltry from the North to Constantinople, then the great emporium for European commerce, the trade growing in volume in the following century as the demands of Western Europe increased, whilst the Northern commerce with Germany developed in like manner.

After the beginning of the Crusades in 1096, intercourse between East and West increased and exercised an important influence on commerce generally, especially in articles of luxury, and the appreciation of furs for adornment was now greatly augmented. The upheaval in the political world considerably affected the fur trade of the Norsemen and Danes with Russia, and as a result, the Italians, both Venetians and Genoese, whose commerce had been slowly gaining strength during the two preceding centuries, secured a strong position in the trade from the East. Constantinople rapidly declined in importance as a commercial centre, goods from the Black Sea ports only passing through that city on their way to the marts of Genoa and Venice. By the 12th century furs had begun to be used to a still greater extent, though the finer and more valuable sorts were chiefly confined to royalty and persons of high rank, and restrictions were made in their use, at least amongst the clergy. Furriers are now heard of in increasing numbers, and associations or guilds were formed for the proper regulation of the trade. The Zunft of Kurschner (Guild of Furriers) at Quedlinburg in 1134 is probably the oldest, Rouen (1160) being second and Florence (1197) third.

The fur trade in Europe experienced a further expansion in the 13th century, records and chronicles showing the widespread extent to which the use of furs had then attained. From a very early date German merchants established themselves in London, and later others from the Northern towns of Germany were granted privileges of trading at Bergen (in Norway) at Novgorod (in Russia) and many towns in Flanders, Germany and Russia. These traders were the predecessors of the great Hanseatic League, which from about the year 1280 began to build up its immense commerce of the North. This trade consisted largely of furs, which were exported from Novgorod and other places in the interior of Russia, through the Baltic ports to towns in Germany, England and Flanders, the chief emporia being at Novgorod, Lubeck, Cologne, Brunswick, Dantzic, Bergen, Bruges and London.

During the two succeeding centuries (14th and 15th) the vogue became more and

more accentuated, all classes wearing furs according to their means, while prices advanced in sympathy with the demand. So great was the indulgence in the use of these and other objects of luxury during this period, that a succession of sumptuary laws were passed in nearly every country of Europe with the object of checking extravagance, but in most cases with little or no effect. The trade was now at its zenith and supplies from Russia, Scandinavia, Germany, etc., reached a very large total. Guilds of furriers were established in nearly every town of importance in Germany, France, Flanders, England and Italy: the Berlin Guild was founded in 1280, the Skinners' Company of London received its charter in 1327, and that of Paris, about 1395, though in each of these cities the industry had been established long prior to these dates. Fairs formed an important medium for the distribution of peltry, and were attended by merchants and furriers from all parts; the most notable fairs in the Middle Ages were those at various towns in Champagne and Brie in France, where both Germans and Italians brought their furs for sale at Paris and Bruges, St. Botolph (Boston), Winchester, St. Ives, Stamford and St. Edmund in England. Bruges and Antwerp were at this time the principal entrepôts in the North of Europe for foreign produce, but by the beginning of the 16th century, the trade of Bruges had declined in favour of Antwerp, which in Elizabeth's time was known as the principal market for furs from all parts.

The principal furs of the better class in use in the Middle Ages were European marten, Russian sable, ermine, lettice, otter, budge, beaver and squirrel, of which latter there was an enormous consumption in its various forms and under different names (some of which were Bis, Gris, Vair, Gros Vair, Miniver, Calabre, Cristigrey, Polayne, Ruskyn, Popel and Strandling): of the commoner class, cat, coney, lamb, fitch and fox: foynes, Genet, Lucerne and mink do not make their appearance until about the 16th century.

The following list of explanations of some of the names of furs in the Middle Ages and early modern times may be of interest:—

Obsolete Names of Furs.

Lettice. The white fur of the snow weasel of North Russia: still used in small quantities as a cheaper sort of ermine; the tail is smaller than that of the ermine and has no black tip.

Budge. Black, and sometimes white, lambskin: originally from Bougie in North Africa, but afterwards used to designate any of the more valuable and curly sorts of foreign lambs.

Pampilion. Lambskin from Pampeluna in Spain, probably identical with "Budge of Navarre" in the Customs Accounts.

Bis. The fur of the back of the Siberian squirrel in its winter coat and in its best or dark grey colouring.

Gris. The same, but of ordinary grey colour: also used as a general term for the grey back of the squirrel.

Popel. Squirrel fur in spring, but not of a pure grey colour.

Ruskin. The same in summer time and of quite a reddish hue.

Strandling. Squirrel fur in its autumn coat, tinged with red.

Polayne. Squirrel fur from Poland, the grey of the back a very dark shade.

Calabre. Squirrel skins from Calabria of a very dark grey or black, but poor in quality: the name was used very much later by the British Customs as a comprehensive term for Siberian squirrel.

Vair. A general name for the whole skin of the Siberian squirrel, both grey back and white belly together and generally when manufactured into linings.

Gros-Vair. Really the same, but used to distinguish it from Miniver (Menu-vair).

Miniver (French, menuvair). The under part of the squirrel, with part of the grey sides remaining—the same as the present squirrel lock-lining. The name has for some time lost its former signification and is now represented by ermine, with spots of black fur.

Pured miniver or *puree* was the term used when the grey sides had been removed, leaving only the white belly.

Foynes. The fur now known as stone marten.

Lucerne. Lynx fur, only the underneath part of which was generally used, being whitish with irregular dark spots.

John Cabot, a native of Venice, at the expense of certain Bristol merchants discovered America in 1497. Frobisher, Button, Fox and Hudson had in their attempts to find a north-west passage to India and so circumvent the monopoly of trading in the Pacific granted to the East India

Company, had each succeeded in discovering new lands which bear their names.

It was these discoveries that gave title to the Government by whose subjects or by whose authority they were made, which title might be consummated by possession.

In 1553 the organisation of the Russia Company took place under the title of "The Mysterie and Companie of the Merchants' Adventurers" for the discoverie of regions, dominions, islands and places unknown. The Right Worshipful Master Sebastian Cabot was appointed Governor of the Company, which was the first of the great English joint-stock companies for foreign trade.

King Edward VI. interested himself in this adventure and entrusted Richard Chancellor, who was appointed to the command of the expedition, comprising three ships, with letters to the Kings, Princes and other Potentates inhabiting the north east parts of the world.

Chancellor discovered the Bay of St. Nicholas and delivered the letters from the English King to the Emperor of Russia, Ivan Vasilowich.

These letters were acknowledged from Moscow in the second moneth of February in the yeare 7060 (old calendar) and sent to King Edward in 1554. As a result of this voyage and discoverie of Russia by Chanceler, King Philipe and Queene Marie granted the Russia Company a Charter of trade and a fellowship in Communaltie with a Governor, Consuls and Assistants. Thus our trade with Russia was commenced, but the Company's methods of finance were faulty and there were several reconstructions —its concessions were annulled in 1646, but the fellowship continues to the present day.

The trade opened up between England and Russia had an injurious effect on the Hanseatic League, whose methods were offensive to the Emperor of Russia. Their privileges in England had been greatly modified, but when the Emperor Rudolph ordered the factories of the English Merchant Adventurers in Germany to be closed, Queen Elizabeth in 1598 directed the Lord Mayor of London to close the house occupied by the Merchants of the Steelyard. It may be of interest to note that the site of the steelyard is where Cannon Street Station now stands.

There is little doubt that Siberia's vast wealth in sable and other furs had for a long period excited the cupidity of the Russians, but the conquest of that country was not commenced till the reign of Ivan the Terrible in 1580. From that time various expeditions were sent from Russia, during most of which large quantities of valuable furs were obtained, and from the period when the whole country came into the possession of the Russians, considerable trade developed and though affected by the Great War, exists to the present day.

The discovery of the mainland of North America by John Cabot in 1497 led to the gradual opening up of an entirely new source of supply for the fur trade, and, as the years went on, to a complete revolution in this important branch of commerce. Long before the earliest fur trading companies were formed, Newfoundland fishermen bartered peltry with the natives. Gomez in 1524, from the mouth of the St. Lawrence, and J. Cartier in 1534, from Newfoundland, both brought back furs with them to Europe. From this time onwards, an irregular though increasing traffic was conducted, chiefly by French traders, and in the latter years of the same century assumed dimensions of importance, though still only a coasting trade. In 1599, the first monopoly was granted to Chauvin, who for three years enjoyed large profits, and from 1602, other companies of increasing power succeeded to these rights, none of them lasting any length of time on account of the continued complaints of those excluded from the trade and of the want of any proper attempts at colonisation.

In the meantime, foreign vessels began to take a share in the commerce; the Dutch appeared in the St. Lawrence and robbed the French of their furs. The latter, however, continued to carry on a lucrative business in spite of opposition. The English Virginia Company (created in 1606-9) also began to press upon the French trade from the south, whilst from New Amsterdam (founded in 1614) large quantities of beaver were shipped to Holland. The French in Canada still went on trading under the domination of Company after Company, under De Monts, Champlain, Montmorency, Caen and others. In 1621, the Dutch West India Company was formed and, devoting itself to the fur trade, sent home numbers of skins of all sorts, chiefly of beaver, which was the principal fur in the early days of this commerce. A Scottish and English company was organised in

1628-9 for fur trading in the St. Lawrence, at the time of the war between England and France, leading to seizure of French vessels, raids on settlements and finally, after the fall of Quebec, to the capture of the entire St. Lawrence trade. A few years later, on the restoration of peace, restitution had to be made to the French, though in the meantime their rivals had enjoyed the whole profits from this region. "La Compagnie des Cent Assoces" was granted a charter by Richelieu in 1627, but their trade in furs was in a short time entirely appropriated by the Dutch and other foreigners. La Compagnie exercised control over New France until 1663, when it was ceded to the Crown, and "La Compagnie des Indes Occidentales" was granted a Charter for the Prosecution of the fur trade in 1664, but the country was finally taken under the control of the French King, resulting in rapid progress in colonisation and trade.

In 1664 King Charles granted the territory of New Amsterdam, now comprised in the States of New York, New Jersey and Delaware to his brother, the Duke of York, who wrested it from the Dutch, and the fur trade fell into English hands.

Perhaps, however, the most important factor for the British Empire arising out of the fur trade was the granting of the charter by King Charles II. on the 2nd May, 1670, to Prince Rupert and his associates for incorporating the Hudson's Bay Co. for the purpose of, among other things, the discovery of a New Passage into the South Sea and for the finding of some trade in furs.

The events that led up to the granting of the charter deserve to be more fully dealt with than is possible in a paper of this kind, but as these events secured to the British Empire that vast and loyal Dominion of Canada, and the granary of the Empire, I am impelled to mention it, however briefly.

In 1658, two Frenchmen named Radisson and Grosélliers, who were in the employ of La Compagnie des Cent Assoces became dissatisfied with the limitations of their prospects and commenced trading for their own account without the permission of the Governor. On their return to Quebec Grosélliers was imprisoned and the partners were fined £10,000. On his release, they crossed to France to seek restitution and to obtain support for a voyage to Hudson Bay. Having failed in both these objects, they eventually, through the influence of Sir George Cartwright, one of the Roya Ambassadors in America, obtained an interview with King Charles in 1666 and the support of Prince Rupert.

In 1667 the First Stock Book of the Hudson's Bay Company records that substantial sums of money had been provided for the adventure by such men as Prince Rupert, the Duke of Albemarle, the Earl of Arlington, Earl Craven and others, and, in 1668, two vessels, the "Eaglet" and "Nonsuch" sailed for Hudson Bay. The "Eaglet" failed in her attempt, but the "Nonsuch" sailed through Hudson Bay to James's Bay and established a post at the mouth of Rupert's River, and in 1669 returned to England with a cargo of furs. On the success of this voyage, those who had supported the enterprise applied for a Royal Charter, which, as already stated, was granted on the 2nd May, 1670, to the Governor and Company of Adventurers of England, trading with Hudson Bay.

The first few cargoes of furs were sold privately, but on the 24th January, 1671, the first public sale of furs was held by the Company in London at Garraway's Coffee House. The minutes of the meeting referring to the sale ordered :—"That the substance "of the preamble to the Publick Sale "which is to be to-morrow be that the "quantity of Beaver to be sold is divided "into 27 Lots of about 100 lbs. to a Lot, "the price 7s. per lb. to advance two-pence, "to pay at a month, and not to take away "the goods before payment be made "and that but 3,000 lbs. or thereabouts of "Beaver more is to be sold by the Company "and that not before May next."

From that date down to 1914-15, when there was a slight interruption owing to the Great War, the Hudson's Bay Company have sold their collections of furs in London by public auction and have been in a large measure instrumental in maintaining London as the centre of this important entrepôt trade, the quality and handling of the offerings being such as to command the attention of the fur trade of the world.

The Company was not considered enterprising in exploring the interior, but the chief reason for this apparent neglect was that during the long traverse from the hunting grounds to the trading posts in the spring, when the fur is of inferior quality and the animals rear their young, the Indians were compelled to suspend hunting operations.

During the early years of the Hudson's Bay Co.'s venture, new French trading companies followed each other in endeavouring to secure to themselves the fur trade of Canada and Louisiana, viz., the "Compagnie de l'Arcadie" (or "du Castor") founded in 1683, "de la Louisiane" (or "d'Occident") 1684, "du Mississippi" (1684), the new "Compagnie du Canada" (or "de la Nouvelle France") 1706, (which surrendered its headquarters at Quebec to the Hudson's Bay Company at the Treaty of Utrecht in 1713) and the Cie. des Indes. In 1717, the "Compagnie d'Occident" was joined with the "Compagnie des Indes" and the latter in turn absorbed in 1719 various other French colonial companies, but the enormous undertaking collapsed in 1721, though the company was reconstructed and continued its fur trade. Beaver was the principal article of export of most of these companies, but other furs formed a substantial part. The goods were shipped to French ports, chiefly to La Rochelle, and in 1743 the quantities were still very considerable. The French fur trade in Canada after the cession of the country to England, in 1763, gradually became merged in the North-West Company from Montreal. In the course of its early struggles with the French in Canada and later with the North-West Company of Montreal, the Hudson's Bay Company's trade in furs experienced very uneven fortunes, but after the amalgamation with the latter company, in 1821, a peaceful and prosperous trade was developed and large shipments of furs made to London.

In March, 1778, about 300 years after Columbus discovered America in 1492, Capt. Cook, in command of a Royal Exploring Expedition with the "Resolution" and the "Discovery" discovered Oregon, where the natives were dressed in long robes of sea otter skins. These were traded for pieces of metal, but after exploring in the North, Capt. Cook proceeded to the Asiatic side, where, being no longer in need of warm clothing, the sailors traded their furs with Russian fur traders in Kamschatka.

These beautiful pelts which are now so rare used in the early days to realise less than the land otter, which is about half the size and has about one-third the depth of fur.

Chief Factor—afterwards Sir James—Douglas commenced the construction of Fort Victoria, Vancouver Island, in 1843, a few years after the English navigator, George Vancouver, had circumnavigated the island. For many years the company, by means of the famous steamer "Beaver," traded with the natives along the British Columbian Coast. The "Beaver" was built for the Hudson's Bay Company, and was the first steamer to cross from the Atlantic to the Pacific.

On the settlement of the International boundary Oregon and Washington were ceded to America and the 49 parallel of latitude was adopted for the boundary line, but access to the sea was retained by way of the Columbia River.

The fur trade of the Missouri Valley, though originating under the French early in the 18th century, never developed to any great extent until after Louisiana came into the hands of the United States, and it was largely the result of the expeditions by Lewis and Clark via the Missouri and Rocky Mountains across the continent to the Pacific, in 1804-6, and that of Pike at about the same period from St. Louis up to the Mississippi, which really opened up this fresh field of operations for the fur trade. In 1808, the Missouri Fur Company was founded and rose to some importance under Manuel Lisa. It was reorganised in 1812, but became extinct about 1830. In the same year that the last-mentioned company came into existence, the well-known American Fur Company of New York was organised by John Jacob Astor, a native of Germany. Practically the whole control was in his own hands and it was due to his enormous energy and great business acumen that its affairs rose to such gigantic proportions, Astor eventually crushing all opposition or buying up his competitors. The company made many enemies, whilst its methods were at times open to much criticism. One of its chief rivals, the Rocky Mountain Fur Company, was initiated by Ashley in 1822 and succeeded in establishing a considerable trade in the West, but the undertaking was dissolved in 1834, through inability to stand against its formidable opponent. The Pacific Fur Company, which commenced trade in 1810, was actually only the American Fur Company under a different name for the purpose of conducting the Western trade. The following year saw the foundation of Astoria at the mouth of Columbia River on the Pacific under the auspices of Astor's Company, but the post never succeeded and was sold to the North-

West Company of Canada three years later, during the second American War with Great Britain, the name Fort Astoria being changed to Fort George. The Columbia Company was another enterprise of importance, formed in opposition to the American Fur Company, but after five years' trade was united to the latter. Still another combination of traders, the Mackinow Company, established by the British for operation in the United States, was also bought up by Astor and others in 1811 and re-named the South West Company, in contradistinction to the North West Company. The South West Company and the Pacific Fur Company were practically ruined by the war of 1812-14, and two years later, after the exclusion of foreign traders from the fur trade of the United States, the American Fur Company took over the interests of both these concerns. A few years afterwards, the latter was reconstructed, one portion operating from New York and the other from St. Louis, which had been since 1807 the real centre of the Trans-Mississippi fur trade. Astor, after having amassed an immense fortune, retired in 1834 from the company in which he had taken a leading part for so many years. He foresaw the inevitable fall in the price of beaver, caused by the substitution of silk for fur in the manufacture of hats, and it was only a short time afterwards that the great collapse in price took place. On Astor's retirement, the Northern department of the American Fur Company was sold to a company with Ramsay Crooks as predominant partner and the Western (St. Louis) Department to Pratte, Chauteau and Cie. of that city, though the name of the American Fur Company was still used. In the same year, the Rocky Mountain Fur Company was absorbed in the latter undertaking.

The Russian trade in furs from Alaska had its origin from the time when, following on the discoveries of Vitus Behring in 1728, a Dane who entered the Russian Navy was appointed by the Empress Catherine to command an Expedition of discovery in North East Asia; further exploring expeditions of his returned with considerable numbers of fur seal, sea otter and fox skins from the islands of Behring Sea. From 1748 until nearly the beginning of the 19th century, vessels were sent out from time to time, chiefly from Kamschatka for trade with the Aleutian and other islands, but it was towards the end of the 18th century before any great development of the fur trade took place in these regions. About this time, the Russian merchant, Skelikoff, with whom Baranoff was shortly afterwards associated, made considerable progress in opening up trade and the former's company met with a good measure of success. In the year 1799 the Russian-American Company, which, with headquarters at St. Petersburg, arose from the amalgamation of Skelikoff's and other companies, received its charter from the Emperor Paul, obtaining a monopoly of trade and exclusive right of territory in the new Russian possessions in Alaska and the islands of the North Pacific in addition to Kamschatka. The Emperor himself, besides nobles and Government officials, became shareholders of the company, so great was the interest shown in the undertaking. Baranoff was for many years the leader in the subsequent operations. In 1839 the Hudson's Bay Company leased South Eastern Alaska from the Russian America Company for a term of years. The lease was granted because the company had secured the most strategic fur trade positions and the Russians were anxious to checkmate the Hudson's Bay Company. To this end they built a line of blockhouses, one of which still remains at St. Michael.

Permanent settlements and trading ports or forts were established both on the Aleutian and Pribilof Islands and on the mainlands, resulting in a valuable trade being built up, principally in the furs of Alaska and the Aleutian Islands. These consisted of sea and land otters, beavers, foxes (red, cross, silver, blue and white) martens, minks, black and brown bears, wolverines, lynxes: and, in addition, fur seals from the Pribiloff and Commander Islands. Further supplies of furs were obtained by the company from Kamschatka and all were shipped to Russia or to China, via Siberian ports and Viatka.

Since the discovery of the Commander Islands in 1741 and of the Pribilof Islands in 1786, the skins of fur seals had been secured by various Russian trading companies, without any discrimination as to economy or method in taking. Large quantities taken in the Pribilof Islands had accumulated in 1803, and as the Russians were unable to dispose of such numbers before the skins began to rot, it is said that of 800,000, 700,000 were thrown into the sea. The use of salt for preserving the pelts was not practised

until 1868, although this method had been employed long before in the fur seal fisheries of the Southern Seas. The skins were despatched mostly via Okhotsk to Viatka on the Chinese border, where they were bartered for tea and other Chinese produce. In 1805, killing was stopped for five years with beneficial results, and from 1820 to 1867, the average quantity of skins shipped annually from the Pribilof Islands to England, the United States and China was 42,000. The transfer of Alaska and the Seal Islands by Russia to the United States in 1867 ended the monopoly of the Russian-American Company. In 1870, a twenty years' lease of the Pribilof Islands was granted to the Alaska Commercial Company of San Francisco, who were allowed to take 100,000 skins annually, this company under a different name in the following year securing from Russia the right to take seals from the Commander Islands for a similar period, up to the number of 40,000 to 50,000 skins annually. In 1890, the new North American Commercial Company of San Francisco, succeeded to the next twenty years' lease of the Pribilof Islands, whilst the Russian Sealskin Company of St. Petersburg in 1891 obtained the fresh ten years' contract for the Commander Islands, which was renewed for a like period in 1901. On the expiry of the Pribilof Islands lease, in 1910, the United States Government themselves took over the control of the seal herd. Owing to the destruction of female seals at sea on their way to and from the breeding grounds on the islands by schooners from Victoria, San Francisco, etc., beginning in about 1870 and rapidly increasing down to 1893, the number killed on the Islands had to be considerably reduced in order to prevent extermination. Seizures of British Canadian sealers in the Behring Sea by the United States led eventually to the Paris Fur Seal Arbitration of 1893, the award of which resulted in certain restrictions being agreed to by Great Britain and the United States. But the latter, on the other hand, were unable to make good their claim to the Behring Sea as a *mare clausam* or to their property in the seal herd. The protection thus afforded to seal life was, however, insufficient to prevent further decimation, the Japanese, who were not included in the Paris agreement, now appearing in the Behring Sea, unhampered by the restrictions imposed on the Canadian and United States sealers. Consequently, an International Conference between Great Britain, the United States, Russia and Japan was held at Washington in 1911, and a treaty was signed stopping all further killing at sea for a period of fifteen years, compensation being given to those nations engaged in sea (or pelagic) sealing. On the Pribilof Islands about 20,000 skins are at present taken annually, and on the Commander Islands a negligible quantity, but the herd is steadily increasing in numbers, owing to the cessation of the killing of female seals.

It is doubtful when sealing in the southern hemisphere actually commenced, but at the close of the 18th and beginning of the 19th centuries hundreds of thousands of fur seal skins were taken from the South Shetland, South Orkney, South Georgia, Sandwich group, Falkland and other islands in the South Atlantic or Antarctic Oceans, from Juan Fernandez and Mas-a-fuera Islands in the South Pacific and from the Crozets and Kerguelen Island, besides others from islands to the South of Australia and New Zealand. From 1821 to 1823 320,000 skins were obtained in two years from the South Shetlands alone and, it is said, over 3,000,000 from Mas-a-fuera within seven years. These operations almost resulted in extermination, and few seals are now obtained from these regions, though the breeding grounds on the islands near the Cape of Good Hope and Cape Horn and on Lobos Island still furnish a moderate number, protection having been afforded by the Governments concerned. The greater portion of the skins obtained in the early part of last century from the herds of the Southern Seas were shipped to Canton for use in China, thus enabling English and American traders to compete with the Russians for this market.

The Chinese are said to have invented, as early as 1799, or before, a process of plucking the coarse hairs from fur seal skins and of dyeing the soft under-fur in various colours. Whether this be true or not, "unhaired" seal skins were not used in the English fur trade until about 1815, and then only in small quantities. A person of the name of Thomas Chapman had claimed in 1816 to have discovered in 1796 a means of producing the same result, though for some few years the under-fur was principally used only after being removed from the skin for felting and making into soft articles of

wear. Dyeing the under-fur on the skin was known in London in the year 1816, though no extensive use was made of fur seal skins so treated until later.

Although fur bearing animals are naturally associated with the colder regions of the world, and the choicest kinds are usually found in the cold regions, furs now reach us from many sources unknown to the old traders, and although the principal supplies still come from North America (*i.e.*, Canada and the United States), viz., marten, mink, musquash, skunk, beaver, lynx, otter, foxes (silver, cross, red, white, blue grey), raccoon, bear (black, brown and grizzly), fisher, wolves, wolverine and American opossum, and from Siberia and Russia, viz.:—Squirrel, sable, ermine, foxes, kolinsky, foals, marmot and white hares, we have in addition, China and Japan in more recent years exporting quantities of the cheaper kinds, namely:—"Thibet," lambs, thick furred goats, kids, red foxes, mink, etc. Since 1870 Australia began to send opossum, wallaby, red foxes and rabbits, the quantities shipped now amounting to a large annual total. South America yields nutria, foxes, chinchillas and otters, whilst from Africa come leopards, otters and monkeys. From Bokhara (Asia) are imported in great numbers skins of the valuable so-called Persian lambs. Europe (as formerly) furnishes Baum (pine) and stone martens, fitch (polecat), otters, genet, ordinary lambs and large quantities of red foxes.

Siberian furs, until the Great War, were chiefly brought into the market at certain fairs, the most notable of which were held at Irbit, Yakutsk and Obdorsk in Siberia, and Nijni Novgorod in Russia: these furs are now exported direct to London or New York. At Leipzig, in Germany, there is an annual fair at Easter, at which offerings of furs are made, including purchases made at the London sales, but its importance has greatly decreased, owing to the war.

None of the older fur companies of North America now exist, with the exception of the Hudson's Bay Company, the trade generally being in the hands of private firms or companies. A very large part of American furs come to the London auctions of the Hudson's Bay Company, C. M. Lampson and Co., F. Huth and Co., and other firms. These sales are held periodically and attended by buyers or their agents from the principal centres of the fur trade.

Australian, Chinese, Japanese, South American and African furs are dealt with in a similar manner by Edward Barber and Son, Eastwood and Holt and Henry Kiver and Co.

Thus the world demand which has increased with the population has been met by bringing furs from practically all quarters of the globe. The geographical position of London has proved it to be the most convenient distributive point for the world's supplies of raw furs; added to this, shippers and buyers can rely on the skins being assorted and catalogued in accordance with the Englishman's accepted standard of integrity.

In 1752-60 the average annual collection of mink was 36 skins. The collection gradually increased till 1881-90, when 59,500 skins was the average annual collection. During their last season, the Hudson's Bay Company collected and sold 55,900 skins.

Musquash. For the period 1752-60 the average annual collection of musquash was 93 skins. The collection increased until 1901-10, when the average collection was 837,300 skins.

For the past year the quantity brought to market was 985,700 skins.

The advance of civilisation and the increase in agriculture is leading to the draining of swamps, and will, doubtless, affect the quantities collected of this pelt in the future.

Lynx. In the period 1752-60 the collection in average was 2,700 skins, and the highest quantities were reached in 1881-90, when 32,400 skins was the average annual collection.

Since then the periodic increase and decrease in quantities failed to repeat itself.

Marten in 1752-60 furnished an average of 14,700 pelts, and increased to 118,000 skins in average for the decade 1851-60. For the season just closed only 25,000 skins were offered by the Hudson's Bay Company. Of course, many skins now find their way to other collectors, but there is no doubt that the felling of timber, forest fires, and lack of re-afforestation are responsible for a great diminution in the numbers of this beautiful pelt.

The Buffalo, except for private herds, is now practically extinct. It would have been impossible, however, to develop agriculture and to have countless herds of buffalo roaming the plains.

Much has been done by conservation to protect the beaver, but it stands a grave risk of becoming unpopular with the farmer owing to its wonderful method of damming streams and flooding considerable tracts of country.

The wolf is friend of neither man nor beast, and the Government grant a bounty of $10 per head for every pelt turned in. The fur value, of course, is greater than this, but the lack of sympathy for the wolf causes it to be killed in and out of season.

The breeding and rearing of fur bearers has made great strides during recent years. According to the Dominion Bureau of Statistics for 1922, there were 977 fox farms in Canada with a total of 24,163 foxes. Although the fox has proved the most suited to domestication, other varieties of fur-bearing animals are being raised in captivity—mink, raccoon, skunk, marten, fisher, beaver, musquash. In the States of America there are 350 fox breeders and in the Alaska region some 200. Our American cousins signalled their entry into this business by placing a 60% ad valorem duty on silver fox skins imported into the country, and so emphasised the slogan "America for the Americans."

In the case of some of the smaller animals, there is not the same danger of extermination since these seem to thrive and breed freely in proximity to civilisation. We must also take into account the increasing number of more or less domesticated animals which now enter largely into the fur trade, such as the so-called "Thibet" and other sorts of lambs, goat and dog skins, white rabbits from China, common cats from all countries, besides the finer lambs from Bokhara, Persia, etc., and rabbits from Australia and all parts of Europe.

There are 12 permissible trade names for various kinds of lamb skins used in fur manufacture, while the rabbit or coney boasts as many as 13 approved descriptions.

The coats of fur-bearing animals are at their thickest and best in winter and towards the close of the season are in the primest condition. All skins are brought to the market in the raw or undressed state, with the exception of some of the Chinese furs.

The dressing and dyeing of fur-skins has been gradually brought to a high state of perfection, the processes of which are carried on in most countries where there is a large consumption of furs. Certain work, however, is still confined to special localities: squirrels, for instance, have for many years been dressed and manufactured into linings almost exclusively at Weissenfels, near Leipzig, but also in Russia. London remains pre-eminent in the unhairing, dressing and dyeing of fur seals.

The prices of all furs, though fluctuating considerably from time to time according to supply and demand, have during the last eleven years been greatly enhanced, with few exceptions, though the figures in January, 1920, may be said to have represented the high-water mark of the fur trade. Taking the year previous to the war, 1913-14, as a standard of 100, the present value shows an increase of 100 per cent.

TOTAL NUMBER OF SKINS SOLD IN LONDON FUR SALES SEASON 1923-4.

Regular Sales.			
Autumn, 1923	.. 3,538,864		
Winter, 1924	.. 3,939,141		
Spring, 1924	.. 4,863,431		
		Total Regular	12,341,436
China Sales.			
Autumn, 1923	.. 1,709,155		
Winter, 1924	.. 1,692,551		
Spring, 1924	.. 1,320,356		
		Total China	4,722,062

AVERAGE ANNUAL QUANTITIES OF EACH DECADE.

	1752-60	1851-60	1901-10
Beaver	34,089	73,659	38,917
Fisher	—	5,884	3,296
Fox	1,407	14,878	16,633
Marten ..	14,763	118,551	46,087
Mink	36	47,213	44,305
Musquash ..	93	314,519	837,369
Otter	1,283	11,243	7,584

PRICES.

	1912-13 £ s. d.	1919-20 £ s. d.
Beaver	1 10 0	6 17 0
Fisher	6 6 9	22 10 0
Fox Cross	3 6 6	24 5 0
,, Red	1 18 3	9 5 0
,, Silver	64 10 0	73 7 0
,, White	3 8 0	13 0 0
Marten	2 4 0	10 6 0
Mink	1 4 6	2 18 0
Otter	4 13 6	10 18 0
Musquash	2 0	13 1

OFFERINGS AT LONDON FUR AUCTIONS BY:

HUDSON'S BAY COMPANY, C. M. LAMPSON & CO., F. HUTH & CO.

August, 1924.

Badger	7,000
Bear	14,000
Beaver	62,500
Ermine	219,300

Fisher	2,200
Fitch	90,000
Fox, Blue	2,700
,, Cross	11,700
,, Jap	11,200
,, Red	312,000
,, Silver	11,100
,, White	62,700
Hares, White	500,000
Kolinsky	11,300
Lamb, Persian	598,200
Lynx	9,700
Marten	23,600
,, Baum	2,600
,, Shire	14,900
Mink	178,900
Mole	709,000
Musk Ox	140
Nutria	110,400
Otter, Land	19,800
,, Sea	42
Sable, Russian	7,900
Seal Fur	9,600
Squirrel	1,107,000
Wolf	89,800
Wolvern	1,590
Musquash	4,691,000
Opossum	1,135,000
Raccoon	39,600
Skunk	2,204,000

DISCUSSION.

The Chairman (Mr. Ernest Poland) said he was sure he was voicing the feeling of the audience in thanking the author for his most instructive paper, on which he must have bestowed a very great deal of care. In dealing with such a subject it was most difficult to concentrate into the small compass of an hour's lecture the very large amount of material which was available.

He drew the attention of those interested to a small volume which he had in his hands, entitled "Illustrations of Arts and Manufactures, being a selection from a series of papers read before the Society for the Encouragement of Arts, Manu factures and Commerce"—which was the full title of the Royal Society of Arts. The book had been published in 1841, and one of the lectures dealt with the subject of "Furs and the Fur Trade," delivered on the 26th January, 1830. No doubt, the volume found its place on the shelves of the Library of the Society, and anyone interested would be able to peruse it.

The Secretary thought it would be interesting if he read a footnote to the title of the paper to which Mr. Poland had referred. It read as follows:

> "For the splendid specimens of furs exhibited on this occasion, the Society is chiefly indebted to Messrs. Poland, of 21, Bow Lane."

Mr. Walter Martin said he recollected the last shipment of fur seals from the Pribilof Islands arriving in London to his old firm of Oppenheim and Co., in Bermondsey, in the year 1869. The date given in the paper with regard to the use of salt was 1868. He thought the furs to which he had just referred must have come in a salted state for a good many years before 1869, and consequently that the author was a little inaccurate in his date in that respect. The dyeing of fur seals in those days had been done chiefly by a man named Appold, who was an engineer, and who had invented the centrifugal pump by which some of the fens in Lincolnshire had been drained. He was rather proud of Appold having been in the fur trade, because it was Appold who had really enabled the first successful laying of the Atlantic cable. Appold had gone out on one of the vessels on which the cable had been broken away as it had been paid out, and he had suggested a certain method of retarding the cable and holding it up, thereby lessening the strain on the cable as it was paid out of the ship. The success in laying the cable had been really due to that suggestion.

The Chairman said there was one question he would like to ask. What did "sale by the candle" mean?

The Author replied that the candle used on such occasions had certain notches in it all the way down. A pin was put in at the notch. It took a certain number of minutes for the candle to burn down to the notch, and the last bid before the pin fell out secured the lot.

The Secretary remarked that, in common with a good many other people, he had always been troubled, when admiring the beautiful furs of beavers and such animals, by the idea that there was a great deal of cruelty involved in the trapping of those animals. He did not know whether or not that was so, and he would very much like to be informed. In such places as Northern Canada he understood traps were set which were only visited at fairly long intervals, with the result that animals caught in the trap soon after it was set, were kept in very great torture until they died. He would very much like some information on that point.

The Author said it was a very large and difficult question to answer. Right from the inception of things, traps had been used for catching animals. There was no unnecessary cruelty; there was no torture or anything of that sort. In a cold climate an entrapped animal did not live for many hours. A beaver caught under water could not live for many minutes because it could not breathe; its struggles were very quickly over. There was no torture employed by the Indian or by the native; he did not know so much about the white man, who had different methods entirely. That was shown in the course of the handling of the skins. Those in the trade could tell the difference immediately between an article handled by a white man and an article which had been handled by the natives; on the latter there was hardly a blood mark. The longest time a beaver could live under water without breathing was five minutes, and if it was struggling

in a trap its breath would go very much quicker. If a native saw a beaver swimming right up out of the water he knew it was right to shoot it; but if it was swimming low in the water he knew it was carrying young and he did not shoot it. The native had so to farm his stuff that he could live next year and the year after that; he did not go out to kill anything and everything. He could not allow it to go forth that the native Indian or the native Eskimo allowed the least cruelty to be exercised in the prosecution of the trade. In his journeys he had seen nothing to which anyone could take exception.

Mr. Walter F. Reid, F.I.C., F.C.S., said he gathered from the paper that a very large number of squirrel skins were sent to Germany to be dressed, and he desired to ask why it was that such an industry was not promoted and carried on in this country, where there was plenty of chemical talent. Personally, he had had no difficulty for the last 50 years in dressing the skins which he had obtained, and he was sure there were a number of chemists here who were quite able to undertake similar work.

With regard to the future supply of furs, it was clear that many of the fur-bearing animals were dying out, but there was one animal now becoming numerous here, namely, the grey squirrel, which had spread all over the country and, from all accounts, was doing a considerable amount of damage. Personally, he had lost the greater part of his filberts last year through their ravages. For the last ten years he had been breeding cats for their fur, and he had now a breed of black cat without a speck of white on its fur, which fur was very like sealskin indeed. Of course, he would not dream of selling it for a sealskin, but still it was a very good warm fur with very thick hair. He had thought he could employ those cats in frightening away the grey squirrels, to which he had just referred, and he had therefore put them into the orchard where the filberts were. The following week he went down to see developments, and he had found the cats playing with the squirrels. It seemed, therefore, there was no obstacle to getting the grey squirrel to flourish in this country.

One thing ought to be impressed upon everybody who had to deal with fur-bearing animals, and that was to protect them during their breeding periods. It was good for the fur trade and for humanity at large that the great crime of exterminating those beautiful animals, which supplied civilisation with raiment, should not be allowed to be committed.

The Author, dealing with the question of protection, said the Canadian and other Governments had their close seasons for fur-bearing animals and on some occasions there was a complete cessation of killing for a period of years together. For instance, the Peru Government entirely protected the chinchilla and would not allow it to be exported.

The Chairman said, with regard to squirrels in this country, which had been mentioned by Mr. Reid, he believed they were the large grey American squirrels. They had multiplied enormously, but, unfortunately, their skins were too common for the fur trade, and it was not worth while encouraging the breeding of such animals.

Mr. G. Rice, dealing with the question of why skins were sent to Germany to be dressed, said prior to the year 1914 Great Britain, France and Germany, to name three of the principal fur trading countries, had each their own speciality in the preparation of various furs. France was particularly famous for the handling of musquash skins and rabbit skins. Owing to the acuteness of her chemists, France was able to prepare those skins better than Germany or any other country. Great Britain also had its own speciality, such as the handling of sealskins. Sealskins had always been handled, dressed and dyed for sale purposes in this country in a way superior to that of any other country. America and France had, with more or less success, tried to handle sealskins but they had never yet been able to equal the product of this country. Germany had played a very great part in pre-war days in the dressing and dyeing of furs. Her chemists were noted for their wonderful dyes, and French and English dyers had had to rely to a great extent on products from the German factories for their colours for furs. During the war, however, an enormous amount of raw skins, which in the ordinary way would have gone from this country to Germany for dressing and dyeing, had been kept in this country. The dressing and dyeing industry in this country had thereupon immediately started to expand and improve in every possible way. During the years of the war, and for two years afterwards, the dressers and dyers in this country had made very great progress. The dressing of squirrel skins had been particularly a German speciality in pre-war days, but now those skins could be dressed in this country quite as well as they had been in Germany. Unfortunately, however, owing to circumstances beyond control, that was to say, the fluctuation of currency and the depreciation of the German mark, quite a considerable amount of dressing and dyeing of furs had gone back to Germany. If the industry in this country was given the same chances as the German industry, he was quite sure it could not only equal, but beat the German industry in nearly every respect.

Votes of thanks to the lecturer and to the Chairman were then put and carried unanimously.

The Author, in acknowledging the vote of thanks, expressed his gratitude to the Chairman for the very great assistance and information which he had given him, especially with regard to the history of the trade. Mr. Poland was the head of a firm which had existed for over 140 years. It was one of the finest firms in the trade. Mr. Poland was a man who not only looked at the monetary side of the fur trade, but had always taken

an interest in the zoological and technical sides of the industry.

THE CHAIRMAN in acknowledging the vote of thanks to himself, said he did not think he could tell Mr. Ingrams anything which Mr. Ingrams did not already know. But he had to admit that he was extremely interested in the historical and natural history parts of the subject as well as its other phases.

OBITUARY.

SIR HARRY JAMES VEITCH.—Sir Harry James Veitch, whose death took place on July 6th, was born at Exeter in 1840. After attending the Grammar School of his native city for a time he was sent, when 14 years old, to Altona, to study German, and later on he was placed with the well-known horticultural firm of Vilmorin, in Paris. Returning to London at the age of 18, he joined the business which his father had established in Chelsea, and which rapidly became well-known throughout the horticultural world by its enterprise in sending out collectors to secure new plants in the Far East, California, and South America.

The death of his father, in 1869, left the whole business in the hands of Mr. Harry Veitch, which under his management rapidly expanded. The hybridisation of orchids became a special branch in which he was very successful. The process of hybridising and of raising the seed had been a trade secret, but in 1884 Sir Harry decided to communicate his firm's knowledge to the world, and he read a paper before the Royal Horticultural Society in which the whole process was revealed.

Mr. Harry Veitch took a keen interest in organising the two great international Horticultural Exhibitions, the first of which was held in 1866 and the second in 1912. Both of these were extremely successful, and shortly after the latter, Mr. Veitch received the honour of a knighthood. He also received the Order of the Crown from the King of the Belgians, the French Legion of Honour, the Victoria Medal of Honour in Horticulture, the French Isidore St. Hilaire medal, and the United States George R. White gold medal for eminent services to horticulture. He was a corresponding member of almost every European and American horticultural society.

Veitch's "Orchidaceous Plants" and "Manual of Coniferae," both standard works, were compiled by him with the assistance of Mr. A. W. Kent, of his firm's staff. The *ampelopsis Veitchii*, one of the most popular of creepers, was introduced by him, and will keep his name green amongst gardeners for many generations.

Sir Harry Veitch was elected a Life Member of the Society in 1871, and he contributed £25 to the fund for purchasing the Society's House.

NOTES ON BOOKS.

INDEX TO "INDIAN ANTIQUARY."—Vols. I.-L. (1872-1921). Compiled by Lavinia Mary Anstey. Bombay: British India Press. To subscribers, *Indian Antiquary*, Rs.6, non-subscribers, Rs.9.

When, in December, 1921, that indispensable Journal, the *Indian Antiquary*, completed its fiftieth year, the Editor-Proprietor, Sir Richard Temple, announced that general indices to the existing volumes were under preparation. They have now been issued in three parts: Part I.—Authors' Index; Part II.—Subject Index; Part III.—Illustrations. Parts II. and III. form a separate volume. A large portion of the excellent subject-index is devoted to inscriptions, general, copper and stone, together with notes, including discussion of dates and identification of places. The hope expressed that the entries relating to inscriptions and the dynasties and eras concerned with them will be found specially valuable to students in the future cannot fail to be realised. From Sir R. Temple's explanatory pamphlet referred to above we learn that the *Indian Antiquary* has always been conducted on an honorary basis —a veritable labour of love. "No one has ever been paid for a contribution or as an editor, or as an assistant of the editors, while the proprietors have contributed towards the cost of the Journal, sometimes heavily, despite the assistance received from time to time by way of subscription for copies accorded by the Secretary of State for India, the Government of India, and its subordinate Governments, and by the Native Rulers." The founder of the *Indian Antiquary* was James Burgess; for some years it was jointly conducted by John F. Fleet and Sir R. Temple, who became sole editor-proprietor in 1892. In the period covered by the Index, the total number of contributors was 527, while nearly as many plates of inscriptions appeared in the Journal itself and upwards of six hundred in the *Epigraphia Indica*, a Government publication which for many years was produced as an official quarterly supplement of the *Indian Antiquary*. The agents of the Journal for Europe and America are Messrs. Bernard Quaritch, Ltd., 11, Grafton Street, New Bond Street, W.

BEET SUGAR AND FRUIT GROWING INDUSTRIES OF SLOVAKIA.

From the report on Slovakia and the Ruthene Territory by H.M. Consul at Bratislava, it appears that the beet sugar industry is of great importance. There are nine factories in Slovakia and their production in 1923 is stated to have been 1,033,826 quintals of crystallised and refined sugar and 106,165 quintals of raw sugar. Formerly this industry was highly protected. It has been established, notably in France, that the growing of sugar beet—because of the intensive use of fertilisers and the careful weeding which it involves

—improves the soil to such an extent that it yields as much as before plus, during the same period, a crop of beet. To encourage this cultivation the late Austro-Hungarian Government enabled the manufacturers to export their surplus production at less than cost price, without regard to the home demand. Now, however, the price of sugar in the home market is fixed by the Government at a comparatively low figure, and only the surplus over the home demand may be exported. The principal profit therefore has to be made in open competition in the world's market. In 1923 all the factories in Slovakia did well.

Fruit growing in Slovakia, says the Consul, might be developed into a profitable export business. A census of fruit trees held in 1920 showed that there were then in this part of the country about 2,820,000 plum, 1,250,000 apple, 770,000 pear, 640,000 cherry, 335,000 nut, and 120,000 apricot trees.

The Government is encouraging the cultivation by maintaining six technical schools for fruit farming. It distributed besides, in 1923, 30,000 young trees at a nominal cost. Fruit has, so far, been chiefly grown for the purpose of distilling spirits. Though fresh fruit is supplied to markets near at hand this is not a very profitable business and frequently it has to be used for feeding pigs or is allowed to rot unpicked. A trial consignment to England in 1923 proved a failure owing to the total lack of experience in packing. Until proper methods are adopted British importers would be ill-advised to allow themselves to be tempted by low quotations.

ASPHALT IN CUBA.

Seepages of oil and liquid asphalt and veins and deposits of solid asphalt are found throughout the whole length of Cuba in all the six provinces. The best known and most developed of the solid asphalt mines writes the Acting British Consul-General at Havana, is situated near the port of Mariel, some 35 miles west of Havana. This property, which covers a very large area, is owned by a British company, and is operated under the direction of a British firm of mining engineers. Difficulties of transport and finance have tended, together with other factors, to retard the development of this mine. However, it is estimated that 70,000 tons of asphalt had been mined and shipped from Mariel prior to 1914. During the war operations were suspended, and were not renewed until 1919, when one of the the veins was attacked by a shaft and underground galleries at a depth of 200 feet. At this depth the vein has so far been opened up for a length of 700 feet, varying from 25 to 35 feet in width. It has been traced on the surface for over 3,000 feet by open pits, and at one point shows a maximum width of 70 feet. A bore hole on the vein showed asphalt at 450 feet.

Since this vein is only one of many known veins on the property it is apparent that the owners have an almost inexhaustible supply of material.

The same company owns valuable asphalt properties in the province of Havana and at Bahia Honda, Pinar del Rio, neither of which is being operated at present.

In the Bay of Cardenas are large deposits of a remarkably pure bitumen, and about 30,000 tons have been extracted without appreciably reducing the deposit, which is fed by springs from below.

Near Cardenas there are also wells that produce 20 barrels of liquid asphalt per day. For this liquid asphalt there is a great opening for use as a fluxing material for the solid asphalts.

The Mariel mines are operated entirely by power produced from burning the asphalt.

GENERAL NOTES.

Manufacture of Knitted Bead Slippers in Germany.—The production of hand-knitted bead slippers, writes the United States Consul at Stuttgart, has been recently attempted in Germany, but the cost has proved too high and the process too slow for practical purposes. However, a firm in Stuttgart is now experimenting with a knitting machine which will enable the production of such slippers on a large and profitable scale, and the machine-made bead slippers will be more evenly and perfectly finished than if the beads are strung and knit by hand. The cost of producing a pair of machine-knitted bead slippers is estimated at £2 12*s*. It is expected that as soon as the problem of suitable machinery has been solved, and the slipper once introduced on the world markets, it will attract wide attention and become universally adopted as a high-class dress slipper.

The Trade of Kenya and Uganda.—The foreign trade of Kenya and Uganda in 1923 shows great progress during that year. Trade imports are valued at £4,302,574, or over £1,420,000 above the figure for 1922, while produce exported, valued at £3,996,432, shows an increase of £1,215,000 over the total for the previous year. The value of coffee shipments rose from £579,061 in 1922 to £620,897 in 1923; of maize exports from £148,910 to almost £250,000; of hides from £50,000 to over £118,000; while sheep and goat skins increased from £23,420 to £34,328. Cotton-seed exports increased from £14,000 to nearly £55,000, and simsim reached the high total of £67,550; but there was a decline in linseed from £7,700 to about £3,800.

MEETING OF THE SOCIETY.

Dominions and Colonies Section.

Thursday, July 24, at 4.30 o'clock:—M. Franck, late Colonial Minister of the Belgian Government, "Recent Developments in the Belgian Congo." The Hon. W. Ormsby-Gore, M.P., will preside.

Journal of the Royal Society of Arts.

No. 3,740. VOL. LXXII.

FRIDAY, JULY 25, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICE.

COMPETITION OF INDUSTRIAL DESIGNS.

An Exhibition of selected works submitted at the Society's Annual Competition of Industrial Designs will be held, by the courtesy of the Director, in the North Court of the Victoria and Albert Museum, South Kensington, S.W., from Saturday, July 26th, to Saturday, August 30th (both inclusive). The designs exhibited are divided into the following classes: Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. The Exhibition will be open to the public free.

The Reports of the Judges, including the awards of prizes have now been received, and it is hoped to publish them in the *Journal* at an early date.

PROCEEDINGS OF THE SOCIETY.

EXTRA MEETING.

WEDNESDAY, JULY 2ND, 1924.

MR. ALAN A. CAMPBELL SWINTON, F.R.S., late Chairman of the Council, in the chair.

THE CHAIRMAN said it was quite unnecessary to introduce the lecturer, for throughout the whole civilised world there was no leader in applied science better known than Senator Marconi. He thought the Society could congratulate itself on the fact that Senator Marconi had chosen that place to read a paper which, he thought, time might show to be a landmark in the history of wireless telegraphy. Two letters had been received which he would like to read, expressing regret for inability to be present—one from Lord Balfour, who still signed himself, "A.J.B.":

"My dear Senator Marconi,—There is nothing which would have interested me more than your lecture on 'Short-wave Directional Wireless,' and I am in despair at not being able to go. But you will understand the position when I tell you that as President of the British Academy I have to preside at our Annual General Meeting on the afternoon of July 2nd, at the very hour at which you are lecturing at the Society of Arts. It is very unfortunate."

The other was from the Secretary to the Prime Minister: "Dear Sir,—The Prime Minister has asked me to thank you for your kind letter of 27th June, and to say that it would have given him great pleasure if he had been able to come to your lecture on 2nd July. It is very, very difficult for him to get away in the afternoons when the House of Commons is sitting, and unfortunately on Wednesday afternoon it is imperative for him to be present in the House. The Prime Minister is very sorry to have to decline your kind invitation in these circumstances, but he knows that you will understand what his difficulties are."

The following paper was then read:—

RESULTS OBTAINED OVER VERY LONG DISTANCES BY SHORT WAVE DIRECTIONAL WIRELESS TELEGRAPHY, MORE GENERALLY REFERRED TO AS THE BEAM SYSTEM.

By SENATOR GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc.,
A Vice-President of the Society.

The study of short electrical waves dates from the time of the discovery of electric waves themselves, that is, from the time of the classical experiments of Hertz and his contemporaries, over thirty-five years ago; for Hertz used short electric waves in all his experiments when he conclusively proved that these waves obeyed the same laws as the waves of light in regard to speed of propagation, reflection, refraction and defraction.

I might also, perhaps, recall the fact that when I first came to England, over 28 years ago, I was able to show to the late Sir William Preece, then Engineer-in-Chief of the Post Office, the transmission and reception of intelligible signals over a distance of 1¾ miles of a beam system emplóying short waves and reflectors, whilst, curiously enough, by means of the antenna or elevated wire system I could only get signals, at that time, over a distance of half a mile.

Many years afterwards, through the courtesy of the Post Office, I was favoured with a copy of the Official Report of those early tests, which, from an historical point of view and in regard also to latest developments, makes now most interesting reading.

The progress subsequently made with the long wave system was, however, so rapid, so comparatively easy and so spectacular that it diverted all research from the short waves, and this, I think, was regrettable, for it has only recently been discovered that these waves, which alone can be in practice confined in beams to definite directions, are capable of results unobtainable by the use of the lower frequency system which up to now has held the field for long distance radio communication.

The late Sir William Preece described my early tests at a meeting of the British Association for the Advancement of Science, in September, 1896, and also at a lecture he delivered before the Royal Institution in London on the 4th of June, 1897.

On the 3rd of March, 1899, I went into the matter more fully in a Paper I read before the Institution of Electrical Engineers, to which Paper I would recall your attention as being of some historical interest.

At that lecture I was able to show that it was possible, by means of short waves and reflectors, to project the rays in a beam in one direction only, instead of allowing them to spread all around, in such a way that they could not affect any receiver which happened to be out of the angle of propagation of the beam, and I described tests carried out before the Post Office Engineers at Salisbury Plain, pointing out the possibilities of such a system if applied to lighthouses and lightships, in enabling vessels in foggy weather to locate dangerous points around the coasts.

I also showed results obtained by a reflected beam of waves projected across the lecture room, and how a telegraphic receiver could be actuated or a bell rung only when the aperture of the sending reflector was directed towards the receiver. (Figs. 1 and 2.)

Since those early tests of over twenty-five years ago, and for a very long period of years afterwards, so far as I can ascertain, practically no research work was carried out, or at least published, in regard to the application of very short waves to radio communication.

Research along these lines did not appear

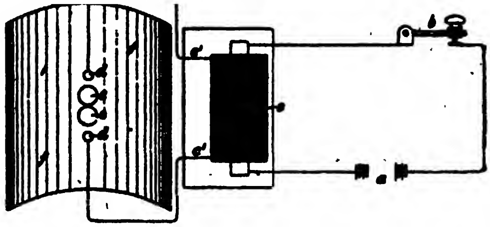

FIG. 1.—Spark Transmitter and Sheet Metal Reflector, 1896.

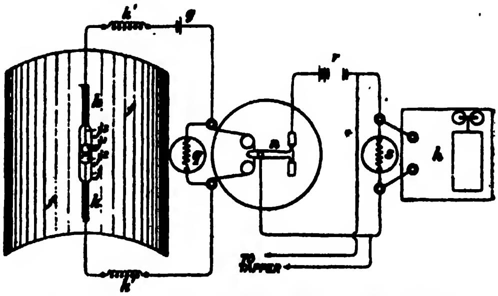

FIG. 2.—Coherer Receiver and Sheet Metal Reflector, 1896.

easy or promising ; the use of reflectors of reasonable dimensions implied the use of waves of only a few metres in length which with the means then at our disposal were difficult to produce, and up to a comparatively recent time the power that could be radiated by them was small. This, and the supposed high attenuation of the waves over any distance of land or sea, gave results which appeared to be rather disappointing.

Some years ago, during the War, I could not help feeling that we had, perhaps, got into a rut by confining practically all our researches and tests to what may be termed long waves, that is, waves of some thousands of feet in length, especially as I remembered that during my very early experiments, in 1895 and 1896, I had obtained promising results over short distances with waves not more than a few inches long.

The investigation of the subject was therefore again taken up by me in Italy early in 1916 with the idea of utilising beams of reflected waves for certain war purposes, as I was greatly impressed with the advantages which such a system would afford in minimising tapping or interception by the enemy, besides greatly reducing the possibility of interference with our own stations.

At subsequent tests during that year and afterwards I was most valuably assisted by Mr. C. S. Franklin.

The Royal Italian Navy also gave me

all possible facilities for the carrying out of my tests in Italy.

Mr. Franklin since then followed up the subject with great thoroughness, and results of his investigations were described by him in an admirable paper read before the Institution of Electrical Engineers on the 3rd of April, 1922.

At a lecture delivered by me before a joint meeting of the American Institute of Electrical Engineers and the Institute of Radio Engineers in New York, on the 20th of June, 1922, in which I described the results obtained up to that time by Mr. Franklin and myself, I felt I could not but express the opinion that it was most regrettable that the study of the characteristics and properties of short waves and their adaptability to directive methods had been so sadly neglected, and pointed out that very many important problems in radio transmission could only be solved by the use of the short wave directional system.

The reflectors now used for this system are not composed of solid sheets of metal, such as those employed in my early tests in 1896, but of a comparatively small number of wires placed parallel to the antenna and spaced around it on a parabolic curve of which the transmitting or receiving antenna constitutes the focal line (Fig. 3), as it was soon ascertained that this was a much more practical arrangement, and that, moreover, much better results could be achieved.

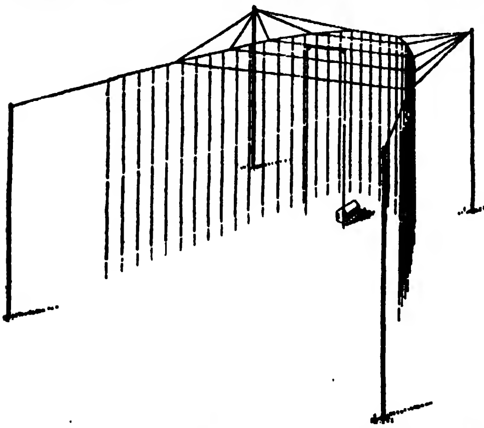

FIG. 3.—Parabolic Vertical Wire Reflector, 1923.

Suggestions for using reflectors of this kind were made by Brown, in 1901, and by De Forest, in 1902, but many essential conditions necessary for efficiency were apparently not realised by these workers at that time, which probably explains why no application of their arrangements was made for practical purposes.

Since 1916 various patents have been taken out by myself and Mr. C. S. Franklin, and in the latest of these Mr. Franklin describes an arrangement in which the antennæ and reflector wires are arranged so as to constitute grids parallel to each other, the aerials or antennæ being energised simultaneously from the transmitter at a number of feeding points through a special feeding system, so as to ensure that the phase of the oscillations in all the wires is the same. It has been proved by calculations confirmed by experiments that the directional effect of such an arrangement is a function of its dimensions relative to the wave length employed. (Fig. 4.)

During my tests of 1916 I used a coupled spark transmitter and the receiver was a crystal receiver. The reflectors employed were made of a number of wires tuned to the wave used, arranged on a cylindrical parabolic curve with the aerial in the focal line.

Reflectors with apertures up to 3½ wave lengths were tested, and the measured polar curves agreed very well indeed with the calculated values.

The Italian experiments showed that good directional working could always be obtained with reflectors properly proportioned in respect to the wave length employed, and with the apparatus then available the range obtained was six miles.

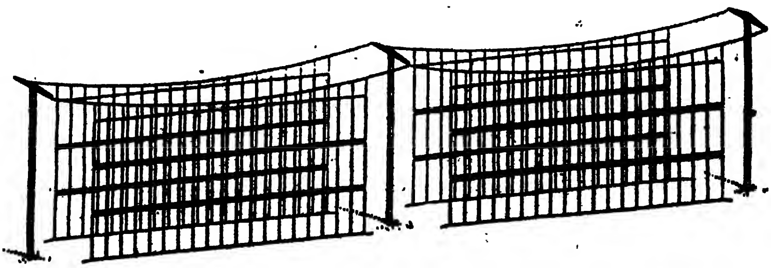

FIG. 4.—Vertical Wire Flat Transmitting Aerial and Reflector, 1924.

The tests were continued in Wales at Carnarvon during 1917, and through the introduction of further improvements, with a wave length of three metres, a range of over 20 miles was readily obtained when using a reflector at the transmitting end only.

In 1919 further experiments were commenced in which Mr. Franklin succeeded in using electron tubes or valves for the generation of very short waves, the object then being to evolve a directional radio-telephonic system.

During further tests, and by utilising a 15 metre wave, clear and strong speech was received in Kingston Harbour, at a distance of 78 miles from Carnarvon.

At a later date these tests were repeated over a land range of 97 miles between Hendon and Birmingham. The power supplied to the valves was approximately 700 watts, and the speech received was strong and of good quality.

The great value of the reflectors was demonstrated by average measurements made, which showed that the value of the energy received when both reflectors were used was 200 times that of the energy that could be received without reflectors.

In April, May and June of last year a series of long distance tests were carried out under my direction between a small experimental transmitting station at Poldhu in Cornwall and a receiver installed on the S.Y. "Elettra."

Mr. C. S. Franklin was responsible for most of the design and operation of the transmitting arrangements at Poldhu, and Mr. G. A. Mathieu was in charge of the receiving apparatus on the yacht, where I also was present during the whole of these tests. Mr. Mathieu was able to make some valuable calculations based on the observed results, especially in regard to the absorption or attenuation of the waves brought about by sunlight.

The principal objectives of these tests were :—

(1) To ascertain the reliability of signals transmitted on approximately a 100 metre wave over considerable distances with or without the use of a transmitting reflector.

(2) To investigate the conditions which affect the propagation of short waves, and to ascertain the maximum reliable ranges obtainable by day and by night in respect to the power and wave length employed at the sending station.

(3) To investigate and determine the angle or spread of the beam of radiation when employing a transmitting reflector, especially with regard to the possibility of establishing long distance directional wireless services.

During the tests carried out on the S.Y. "Elettra" no receiving reflector could be employed, and it will therefore appear obvious that the strength of the received signals and the ranges covered must have been considerably less than could have been obtained had it been possible to use a fixed receiving station equipped with a suitable reflector.

Up to the present time the general impression prevailing amongst most technical experts in regard to the behaviour of short waves is :—

(1) That their range during day time is variable and short.

(2) That the night ranges are exceedingly variable and freaky, and altogether too unreliable to allow of the carrying out of commercial work.

(3) That any considerable amount of intervening land or mountains very seriously reduces the distance at which it is possible to communicate.

The tests carried out between Poldhu and the "Elettra" proved by the definite results obtained that the above mentioned impressions or conclusions must be erroneous, at least in so far as they may concern waves of about 100 metres long, for we observed :—

(1) That the day ranges proved to be reliable and not inconsiderable.

(2) That the night ranges were much greater than anyone, myself included, had anticipated, and no doubt very considerably exceeded the maximum distance to which I was able to proceed with the "Elettra."

(3) That intervening land and large portions of continents do not present any serious obstacle to the propagation of these waves.

In carrying out these tests we discovered that it is by no means correct in dealing with these waves to refer to distances covered during daylight as day-ranges, as the strength of the signals which can be received during the hours of daylight varies definitely and regularly in accordance with the mean altitude of the sun over the space or region intervening between the two stations.

This discovery, based on the observed results makes it safe to infer that our tests

which took place mainly during the months of May and June, and partly within the tropics, were carried out at the most unfavourable time of the year for daylight transmission (as the sun reaches its maximum altitudes during June in the Northern Hemisphere) and over what is a most difficult region.

Perhaps one of the most remarkable scientific results of the experimental work carried out on my yacht was to ascertain quite definitively that the coefficient of the well known Austin Formula for the propagation of the waves was defective when applied to short wave phenomena.

It will be remembered that this absorption factor is an exponential of the form e^{-x}, where -x the negative index is given by Austin as the product of a constant multiplied by the ratio of the distance between the stations and the square root of the wave length used.

Slightly modified values for that constant have been suggested by several scientists during recent years, and a different value has also been suggested for daylight and night communication.*

The results of our measurements and observations are that for short waves of the order of 100 metres this constant must be replaced by a variable, which is approximately a linear function of the mean altitude of the sun calculated on the great circle track between the two stations.

In other words, the coefficient of absorption is a function of the time, the seasons and the relative geographical situation of the stations, and can now easily be ascertained for wave lengths of the order of 100 metres.

Our tests obviously show that short waves behave quite differently in their propagation from long waves, and that the weak period at sunset and sunrise followed by a recovery in signal intensity observed with the long waves over great distances, is not true in the case of short waves.

It also appears that there is probably no sharp limit between short and long waves, and that the change in the behaviour of short waves, of say 100 metres, to that of long waves of, say 10,000 metres, may follow a slow process of transformation.

Very likely over very long distances as the wave length increases there may be a tendency for the signals to recover progressively during the period of no signal, for short waves, and this may form the object of further very interesting investigation.

In regard to the x's and atmospheric disturbances generally, these usually appeared to be, during day time, less severe than those experienced when working with the longer waves up to now employed for practical radio telegraphy.

During night-time, even when receiving at St. Vincent, which is situated at 2,330 nautical miles from Poldhu, and well within the tropics, the strength of received signals was so great that absolutely none of the x's or atmospherics which we there experienced ever approached being able to interfere in any way with the reception of signals or messages from Poldhu.

During the tests to the "Elettra" on 97 metres wave the Poldhu transmitter consisted of 8 glass valves (standard M.T.2) worked in parallel, the input to the valves being 12 kwtts. The radiation from the aerial was approximately 9 kwtts. The parabolic reflector concentrated the energy towards Cape Verde and gave a strength of field in that direction which would have required a radiation of approximately 120 kwtts. from the aerial without a reflector to produce.

For the purpose of the experiment a special receiver with independent aerial was installed and added to the wireless gear of the "Elettra."

The receiving aerial was a vertical wire, the top of which was at a height of 20 metres above sea level.

The receiver consisted of an aerial circuit, a closed condenser intermediate circuit, a frequency changer circuit, two high frequency tuned amplifications and an autoheterodyne detecting valve to which could be added two stages of low frequency amplification.

After carrying out a few preliminary tests in Falmouth Harbour on the 11th April, the "Elettra" sailed for Cape Finisterre (Spain).

A first series of tests was carried out without the transmitting reflector.

After rounding Cape Finisterre it was anticipated that the intervening land would have cut off signals during daytime and also would have considerably weakened them during the night.

These expectations were not verified.

Signals during the day weakened according

*Based on the so-called night effect, which I discovered early in 1902. (See Proceedings of the Royal Society, Vol. LXX., by G. Marconi, June 12th, 1902.

to the distance and the altitude of the sun, but were received right up to Seville (780 miles from Poldhu) although practically the whole of Spain, consisting of over 300 miles of high and mountainous land, intervened between the sending and receiving stations.

The night signals were always so strong as to appear almost as powerful as those received when the yacht was at her anchorage in Falmouth Harbour at only 12 miles from Poldhu.

It should be stated that the yacht, when at Seville, was moored in the Guadalquivir River, in a situation particularly unfavourable for the reception of signals, as the adjacent banks of the river were high and surrounded by trees and buildings.

At Gibraltar (820 miles), notwithstanding the greater distance, a better strength of signals was noticed during the hours of daylight, probably in consequence of the fact that the yacht was anchored in a more open space, and therefore in a more favourable position.

Similar results were also obtained at Tangiers (840 miles) and at Casablanca (970 miles).

I find it almost unnecessary to refer to the night signals, as these were always, and in all places throughout the whole of the cruise, extraordinarily strong and capable of being received at all times without using an amplifier, with the aerial out of tune, or disconnected, or without using the heterodyne.

At Casablanca I telegraphed instructions to hoist the reflector aerials at Poldhu.

The "Elettra" then proceeded to Madeira, but at Funchal was obliged to anchor in a very unfavourable position for the reception of wireless signals from England, being at the far end of the island and immediately under the mountains of Madeira, some of which rise to heights of over 6,000 feet.

On the 17th of May tests were recommenced between Poldhu and the "Elettra," but although the night signals were, as always, extremely strong, I considered it desirable to carry out daylight tests in positions not so completely screened by the immediate vicinity of mountains.

Thus it was ascertained that signals could be received from Poldhu by day up to 1,250 nautical miles when that station was using 12 kwtts. of energy.

On the 21st of May we sailed for St. Vincent, Cape Verde Islands, and although at St. Vincent our anchorage was at a position partly screened by mountains, daylight reception was still possible for a few hours after sunrise and for some time before sunset.

The night signals continued to arrive from Poldhu at all times with apparently unabated strength, notwithstanding that our distance had increased to about double what it was at Madeira, that is, to 2,230 nautical miles.

At St. Vincent, as at Madeira, the Poldhu signals could always be received with the heterodyne or l.f. amplifier switched off.

Mr. Mathieu estimated the strength of the night signals at St. Vincent from 400 to 500 microvolts per metre in the aerial, and with such a strength on the wave length we were using, no trouble was ever experienced in consequence of atmospherics or x's. In fact, for greater convenience, all messages from Poldhu were read with the aerial out of tune or disconnected from the receiver.

At St. Vincent the signals received from the Post Office at Leafield were weak and often unreadable. I therefore gave instructions that all wireless messages addressed to me should be transmitted by our short wave experimental station at Poldhu. No difficulty was ever experienced in the accurate reception of these messages.

As, in consequence of my having to return to England, it was decided not to carry on these tests to still greater distances, I instructed Poldhu to gradually reduce the transmitting power from 12 kwtts. down to 1 kw., but even with this small amount of energy the signals received at St. Vincent were still stronger than would have been necessary for the carrying out of commercial work over that distance.

Mr. Mathieu calculated that the signals would still have been readable at St. Vincent, even should the power at Poldhu have been reduced to 1-10th of a kilowatt.

I might add that the night signals received at St. Vincent, even when Poldhu was using only 1 kilowatt, were much stronger than those received from Carnarvon, or than those which could be received at either St. Vincent or Madeira from any of the other European or American high-power stations.

The signals by night or by day did not appear to be subjected to lengthy fluctuations in strength, nor inclined to give what have been termed freak results. The results obtained could always be repeated over the same distances under similar conditions in respect to the sun's altitude.

Short periodical fluctuations of strength, lasting less than a minute, were constantly observed, but I believe that these variations were mainly caused by slight changes of the wave length determined by imperfections of the arrangements in use at Poldhu, and also by the movements and rolling of the ship at the receiving end.

Although sunrise at St. Vincent occurred about three hours later than at Poldhu, during the period of the tests nothing was observed which would indicate the existence of the weak period so noticeable under similar circumstances in radio reception between Europe and North America.

The results of these tests were sufficient to convince me that it would be possible to carry out reliable commercial services for a large portion of hours out of the 24 over distances of at least 2,300 nautical miles by utilising only about 1 kilowatt of energy at the transmitting stations, and that the practical range of the system, when using 12 kilowatts had not even been approached.

These results were obviously so encouraging that I decided to give the new system very careful study and consideration.

The station at Poldhu was somewhat improved, and the energy employed was increased to about 20 kilowatts.

Since February of this year a further series of tests have been carried out over ranges which included the greatest possible distances separating any two places on earth.

A special short wave receiver was installed on the S.S. "Cedric," and reception tests were carried out with Poldhu by Mr. Mathieu during a journey of this vessel to New York and back. No reflectors of any kind were employed at either end.

For the tests to the "Cedric" the wavelength was 92 metres and the transmitter comprised two oil-cooled valves of special design controlled by an independent drive circuit to ensure steadiness of wave-length. The power supplied to the main valves was 21 k.w. giving a radiation of approximately 17 k.w.

These experiments were conducted with the object of supplementing our information on the general behaviour of short waves over long distances.

The results showed that on the "Cedric" signals could be received during daytime up to a distance of 1,400 nautical miles, and it was confirmed that the signals' intensity is symmetrical to the mean altitude of the sun at all times. As a consequence of this, the day limit of the signals on the "Cedric" was greater than what was observed during the cruise of the "Elettra" because the average height of the sun was much less at that time of the year on the particular track of the "Cedric" compared to what it was on the far more southernly track followed by the "Elettra" during the months of May and June.

Signals of great intensity were received at Long Island, New York, during the hours when darkness extended over the whole distance separating the stations, and of less intensity when the sun was above the horizon at either end, the intensity of the signals varying inversely in proportion to the mean altitude of the sun when above the horizon.

According to the measurements carried out Mr. H. H. Beverage, Research Engineer of the Radio Corporation of America, the average strength of the signals at New York was 90 microvolts per metre.

I might mention that a few days prior to the commencement of these tests between Poldhu and the "Cedric," the Chief Engineers of the Amalgamated Wireless (Australasia) Ltd., of the Marconi Wireless Telegraph Company of Canada, Limited, and of the Radio Corporation of America, had been requested by telegraph to attempt to receive the transmissions radiated from Poldhu in their respective countries.

Rather to my surprise, I must admit, Mr. Ernest T. Fisk, the Managing Director of the Amalgamated Wireless (Australasia) Ltd. reported to me by cable that he could receive the Poldhu transmissions at his house in Sydney every day perfectly well from 5 to 9 p.m. (Greenwich) and also that he had received them between 6.30 and 8.30 a.m., informing me also that for most of the time the signals were clear, steady and strong on an improvised receiver consisting of a 2-stage high frequency tuned plate and grid with one rectification. He also added that he had read every word that was sent and that the signals were better than those he had yet received from the high power station at Carnarvon.

These experiments with Australia were continued during the month of May, consistently good results being obtained at two receiving stations situated in the vicinity of Sydney.

It seems obvious, if we consider the posi-

tion and altitude of the sun, that during the morning period the waves travelled from England to Australia starting in a westerly direction, across the Atlantic and Pacific Oceans, along the longest route, which is approximately 12,219 nautical miles, whilst during the evening period they travelled in an easterly direction over Europe and Asia, along the shortest route, which is about 9,381 nautical miles.

In Canada, at Montreal, reception was found to be possible for 16 hours out of the 24.

These results were so encouraging that I was tempted to try a wireless telephony test to Australia.

With rather experimental arrangements at Poldhu, intelligible speech was transmitted for the first time in history from England to Sydney on Friday, the 30th day of May, of this year.

For the telephone test to Australia, oil-cooled valves were employed for the main valve and for modulating valves. The wave length was 92 metres and an independent drive was employed for controlling the main valves. The total power supplied to the valves was approximately 28 k.w. divided up as follows: 18 to the main valves, 8 to the modulating valves and 2 to the drive valves. No reflector was employed.

A continuous development of the short wave transmitter has been taking place at Poldhu. To utilise considerable power, required the study and development of circuits for paralleling valves satisfactorily, and also the design of special valves. To maintain the wave length steady has necessitated the application and development of an independent drive. These problems have been solved satisfactorily and the production of commercial transmitters dealing with powers up to the order of 50 k.w. now presents no difficulties. Figs. 5 and 6 show the interior and exterior of the small experimental station at Poldhu.

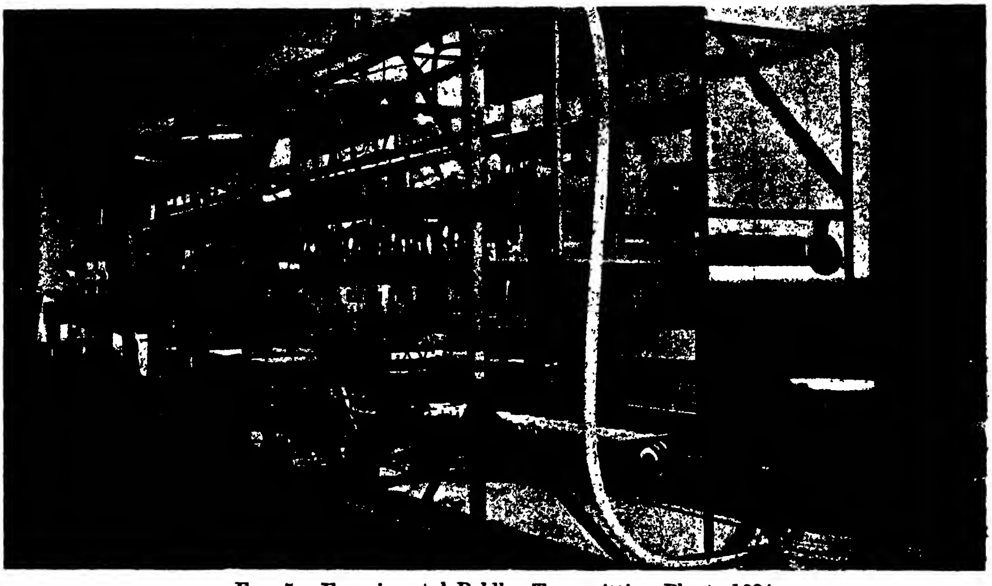

Fig. 5.—Experimental Poldhu Transmitting Plant, 1924.

Fig. 6.—Experimental Transmitting Hut, Poldhu, 1924.

It was gratifying to all concerned that the experiment succeeded the very first time it was tried, Mr. C. S. Franklin being in charge of the transmitting apparatus at Poldhu and Mr. Ernest T. Fisk of the receivers at Sydney.

It is also interesting to observe that these extreme distances were obtained without the use of any reflector at either end.

The results obtained between England and Australia easily constitute a record for ratio of distance to wave length, for Sydney, by the shortest route, is approximately 189,000 wave lengths from Poldhu.

In my opinion it appears to have been proved conclusively that adequately designed reflectors, even if of comparatively moderate size, will enormously increase the effective strength of the signals.

This cannot but augment the efficiency of communication, besides increasing the number of hours during which it will be possible to work with very distant countries.

Moreover, the use of receiving reflectors will be of the greatest advantage to practical working, because whilst magnifying the strength of the received waves they reduce all interference whether caused by atmospheric electricity or other stations, unless, of course, the direction from which the interference may be coming happens to coincide exactly with that of the corresponding station.

The energy magnification, due to the concentration of the energy by the directional effect, has been carefully calculated by Mr. Franklin, and tests carried out at Poldhu have fully confirmed his figures.

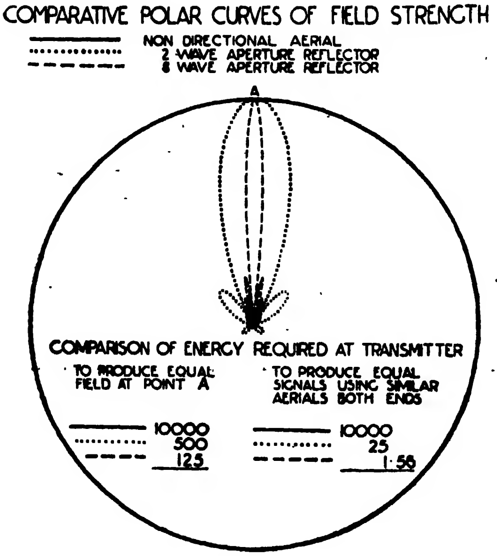

FIG. 7.

Fig. 7 shows comparative polar diagrams of the field in all directions from three different transmitters. The circle is a polar curve of a plain non-directional aerial. The short dot curve shows the polar curve of a two-wave length aperture reflector. The long dot curve shows the polar curve of an 8-wave aperture reflector, such as we propose to use for practical purposes.

The case which was tried experimentally at Poldhu was an aerial and reflector ½ wave high 3 waves wide, the aerial being fed at four points with a cable feeder system. The horizontal polar magnification figure of about 30 was found.

Mr. Franklin has formulated some general laws regarding these aerials, which may be stated as follows:—

(1) The ratio of the loss by radiation to the loss by ohmic resistance, and therefore the efficiency remains constant for all sizes of the aerial at the same frequency. This efficiency figure is very high and can easily be of the order of 80%.

(2) The natural decrement of the aerial is very high, and remains constant whatever the extension, as the ratio of the inductance to the resistance of the aerial remains the same.

(3) The greatest magnification for a given area, and therefore for a given cost, is obtained by having equal areas at the transmitter and receiver. Thus an aerial of 20 square wave lengths at transmitter and receiver gives a magnification of 200, but if divided into two aerials at transmitter and receiver, each of 10 square wave lengths, gives a magnification of 10,000.

(4) For a given area of aerial at the transmitter and receiver, the magnification goes up as the fourth power of the wave frequency used. Thus, assuming aerials 1 kilometre wide and one hundred metres high at transmitter and receiver, these would each be 10 square wave lengths for 100 metre wave and would give a combined magnification of 10,000. For half this wave length (50 metres) each aerial would be 40 square wave lengths and would give a combined magnification of 160,000.

Up to what ranges this fourth power law can be effective in compensating for the greater attenuation of the shorter wave has yet to be ascertained.

The energy capacity of these aerials is enormous and they could never conceivably be worked to their limit. It would be quite possible practically to superimpose

several waves and thus several services on the same aerial.

It should not be lost sight of that very high speeds of working appear to be possible only if short waves are employed, whilst speeds of the same order are quite unattainable with the long waves now in general use for long distance radio communication.

I might, in other words, state that there exists no theoretical reason why with a frequency of 3,000,000, such as is the frequency of oscillation of a 100 metre wave, the speed should not be one hundred times as great as the speed attainable with a frequency of 30,000, which represents the frequency of a wave length of the order of those which it is proposed to use for the Imperial Stations.

Between the 12th and the 14th of June (both inclusive) of this year, some further important tests were carried out between Poldhu and a small receiving station at Buenos Aires in the Argentine, the distance between the two points being 5,820 nautical miles (10,780 kilometres).

Although many of the arrangements employed were far from perfect, very strong signals were received for over ten hours each day at Buenos Aires.

Messages were sent by the Argentine Minister of Agriculture, Dr. Le Breton, who happened to be in London, to the Minister of War, General Justo, in the Argentine, and every message transmitted was correctly received in one transmission.

At the conclusion of the tests we received a communication from the Argentine Committee, representing the wireless interests in the Argentine, who are conducting the wireless telegraph services through their super-power station with Europe and the United States of America, to the effect that the signals from Poldhu transmitted by this new system were received at Buenos Aires with such regularity and extraordinary strength as to permit a service being conducted at any speed, and expressing the opinion that the Argentine station should be immediately equipped with the new system, which, they are confident, will

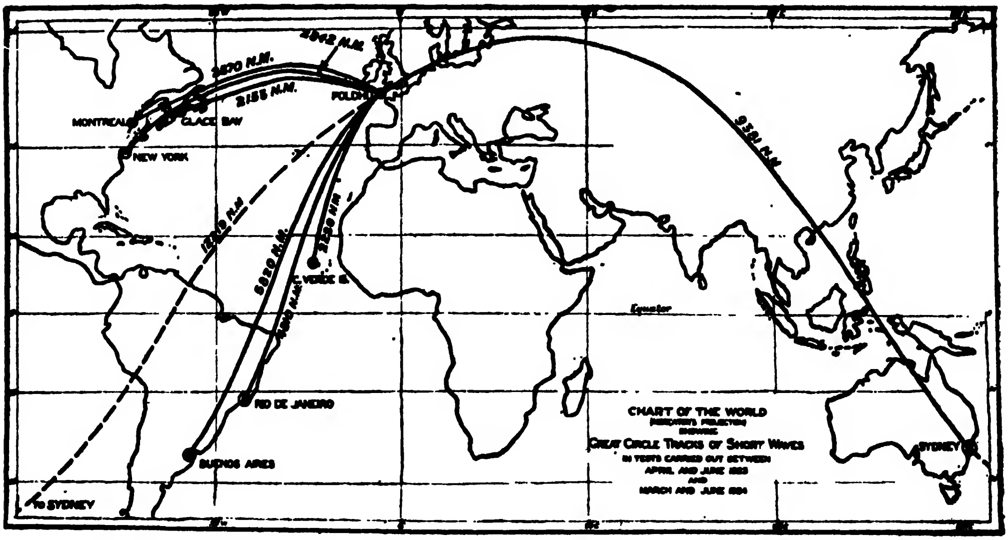

Fig. 8.

For this radio-telegraphic test the wave length was 92 metres and the power to main valves was 21 k.w. This gave a radiation of 17 k.w. The parabolic reflector was employed to concentrate the energy towards South America, and gave a strength of field in that direction which would otherwise have required a radiation of approximately 300 k.w. from the aerial without reflector to produce the same effect.

handle more than double the traffic in six hours than they are now able to handle in twenty hours with their present super-power station. Excellent results were also obtained at Rio in Brazil. (Fig. 8.)

All these results, many of which have greatly exceeded my expectations, convince me that by means of this system economical and efficient low power stations can be established which will maintain direct high

speed services with the most distant parts of the globe during a considerable number of fixed hours per day.

I am further of the opinion that by means of these comparatively small stations a far greater number of words per 24 hours could be transmitted between England, India and her distant Dominions than would be possible by means of the previously planned powerful and expensive stations.

Another particular advantage of this system should not be overlooked. As distant stations situated only within a certain angle or sector of the beam are enabled to receive, this condition brings about a comparative privacy or secrecy of communication unobtainable with any other system of radio communication, and this may prove to be of the greatest value in war time, besides considerably increasing the number of stations it will be possible to work, by reducing the possibilities of mutual interference between them.

The comparative economy in capital cost of these stations, the small amount of electrical power which need be employed, together with the capability of working at very high speeds, should make it possible to bring about a substantial reduction in telegraphic rates. The importance of this to the Empire must be obvious.

I wish to take this opportunity of expressing my high appreciation to Mr. C. S. Franklin for all the valuable work he has carried out in order to make this system a practical success, and also to Mr. G. A. Mathieu for his practical and theoretical assistance.

I also wish to thank Mr. Ernest T. Fisk, the Managing Director of the Amalgamated Wireless (Australasia) Ltd., Mr. H. H. Beverage, Research Engineer of the Radio Corporation of America, Mr. J. H. Thompson, Chief Engineer of the Marconi Wireless Telegraph Company of Canada, Ltd., Commander J. Lloyd Hirst, Marconi's Wireless Telegraph Company Ltd.'s Representative on the Commercial International Committee in the Argentine and Mr. P. Eisler, Manager of the Cric Construction Co., Ltd., contractors for the High Power Stations of the Commercial Radio International Committee in Brazil, for their most valuable co-operation in arranging at very short notice to successfully receive in their respective countries the signals transmitted from Poldhu.

DISCUSSION.

Admiral of the Fleet Sir Henry Jackson, G.C.B., K.C.V.O., F.R.S., said that Senator Marconi had given some notable, and he might say historic lectures in that room on the subject of wireless telegraphy, but few which could equal that which he had given that day. It was not that the subject-matter was all new; people had been working on 100-metre waves for some time, but he did not think they had ever anticipated getting the results which Senator Marconi had obtained by his systematic study of them in the last few years. It was difficult to follow a paper when one did not know the contents beforehand, so he would not attempt to go into details. He would read the paper with very great interest when it was published. He thought it went far to show that the Austin-Cohen formula would have to be carefully reconsidered. It was evident from what the lecturer had said that another factor had to be brought into account, namely, the sun's altitude—and that factor had apparently a great effect on the short waves. He had not been quite able to catch what Senator Marconi had said about the long route and the short route to Sydney, but it was very interesting to know that there was a long and a short way. The Marconi Company had very courteously helped him a few years ago when he was considering wireless telephony on the Radio Research Board. The Company had given the result of their experience of short waves, and Mr. Franklin himself had explained to the Board his views, but he did not know whether he had then expected to get such results as had been set forth in the lecture. Senator Marconi's work would bring the distant parts of the Empire into closer touch with each other. The technical part, of course, required very deep study indeed. It was very evident that the short-length waves had come to stay, and would be of very great commercial value. One of the things which had struck him most in the short wave length was the speed of working, so that the signals could be recorded automatically. One would never have thought that the strength would have been great enough at very long distances. He heartily congratulated Senator Marconi and his assistants on the very marvellous piece of work which they had just accomplished.

Professor J. A. Fleming, F.R.S., said that he had only seen the paper just before the lecture began, and he felt some diffidence therefore in commenting on it. On those rare occasions on which Senator Marconi spoke in public he always described some epoch-making researches, in which he stood head and shoulders above everybody else. It was very interesting to note that in these researches he had described, the great advance he had achieved had been made by moving in an exactly opposite direction to that of all previous research. He well remembered, although it was now a quarter of a century ago, Senator Marconi's first address to the Institution

of Electrical Engineers in 1898 or 1899, when he described his cross-Channel experiments, and showed his early experiments, with little copper mirrors, and described the tests he had made over a distance of about 1½ miles. But at that time the public and scientific interest was concentrated on achieving greater and greater distances, and it was very soon found that for this longer wave lengths were necessary, and therefore Senator Marconi and others went on increasing year by year the wave-length, until, in the last and latest big stations, it was something like ten miles. But having advanced as far as seemed practicable in that direction, he had turned round and gone in the opposite direction, and come down to wave-lengths even smaller than those used in the first cross-Channel experiments, with the result that he had been able to show a very remarkable and interesting advance. There was no knowing whether the limit had yet been reached of the important qualities of the short waves. Until a little time ago there had been a great gap between the shortest wireless waves and the longest dark-heat waves, which was about one-third of a millimetre, but two American scientists had lately succeeded in filling up that gap and making wireless waves of less than a third of a millimetre wave-length, and in the same way at the other end of the spectrum experiments had given shorter and shorter wave-lengths; so that now we were acquainted with a spectrum of nearly 50 octaves of electro-magnetic waves; and it was interesting to know that the researches which Senator Marconi had described were made about the middle of that gigantic spectrum. The great importance of the researches seemed to be not merely in limiting the direction of the waves, but in greatly limiting the power. The figures which Senator Marconi had shown on the diagram before them were eloquent to every wireless engineer of the enormous importance of limiting the power required. It was becoming a very great question at the present time as to how many more high power wireless stations the ether could accommodate. It was becoming rather fully loaded up, even now, and there was probably not an unlimited possibility of putting up stations in the world without making such a disturbance in the ether that nobody would be able to do anything. Senator Marconi's researches seemed to have, in addition to the importance of limiting the direction of the waves and limiting the power, the great value of making more room in the ether; and if that was the case it might become a very little desired thing to put up more all-round stations; and, in fact, the General Post Office might soon prevent it, and no one would think of putting up big stations radiating all over the world in order to communicate with a given point. The Trinity House lighthouse engineer would not think of putting up a gigantic light illuminating all round merely to illuminate a particular channel and guide ships in a particular direction. That seemed to him to be one of the directions in which these new researches would open out a fresh field of work, in that they afforded a still greater, and almost unlimited, possibility of putting up wireless stations.

Mr. C. S. Franklin said he had worked with and for Senator Marconi on the subject of short waves for some eight years, first of all in Italy, then at Carnarvon, then at Portsmouth, then again at Carnarvon, and after that at Inchkeith, Hendon, Birmingham, and finally Poldhu. He had published, in 1922, a paper before the Institution of Electrical Engineers which described some of the results which had been obtained. At that time with regard to knowledge which had been collected by himself and by other investigators there was no indication that waves of the order described would be capable of giving useful commercial ranges such as to Australia or to South America, and the results obtained by Senator Marconi on his trip on the "Elettra," in the early part of last year, certainly marked a real discovery which was not known before. The subject of directional wireless telegraphy and reflectors was one which had fascinated him for some years, and he was only going to say that he was very glad to have played some useful part in Senator Marconi's work.

Mr. E. H. Shaughnessy, O.B.E. (General Post Office), said the paper was a very fascinating one, and full of interesting experimental results. Perhaps the point that had struck him most was the fact that the very short waves, when transmitted from Poldhu, did not vary and fade during any period at all, but were regular and constant. Of course, quite a lot of experimental work was being done on the reception of short-wave wireless by amateurs, and even by the British Broadcasting Company; recently there had been a display of reception on about 100 metres from Pittsburg, relayed in this country. In that particular instance the fading had been most marked, and he thought the power used by the station K.D.K.A. was of the same order as the power at Poldhu—somewhere between 15 and 20 k.w. on about 100 metres. The day ranges obtained by the short waves did not seem to him anything striking for the power that was put into the set. They were certainly striking as ranges for short waves, but for the power put into the set he thought the various companies which supplied ships with continuous wave installations of about 1½ or 3 k.w. would claim that their ships could work certainly over 1,200 miles day and night; they generally grumbled if their ships did not work to the Devizes station over 1,200 miles.

Another interesting point that struck him was that most of the experiments, those to Montreal and to Sydney, were done without reflectors; so that one had an ordinary station working on 100 metres and working with something like 18 k.w. input, which was able to give a world-wide range—just an ordinary short-wave set. Anyone who had not to deal with wireless matters might not appreciate how much had had to be done to get an efficient transmitter of such a power on such a wave

length, and to design an aerial which would efficiently take that power and radiate that wave-length.

Senator Marconi had said that somewhere at Gibraltar, or even at Cape Verde, reducing the power at Poldhu to some insignificant figure—much less than the 9 k.w.—the signals were still as strong as ever. That was what he had understood, and if that was so it was interesting to note that despite the calculations made by Mr. Mathieu, the power at Poldhu was increased from 9 k.w. to some figure about 18, and Senator Marconi was even contemplating a 50 k.w. station. That, he thought, was quite wise, and he was quite sure that Senator Marconi and his very able assistants would not rest content with having at their disposal what they had at present. It was an experience that wireless had shown that under certain limited experiments, carried over a limited length of time, one could not conclude that the results would always be the same. He thought the earliest experiment cross the Atlantic on long-wave was done with something like 3 k.w. Then Poldhu was built, and then from that one got on to much larger stations. It might be that such large stations would never be wanted for the short-wave services; but he thought it was wise to consider the development of as full a power as one could get, even up to 50 k.w.

It had been suggested that the short-wave stations would eliminate all high-power stations, and that all radio-engineers and power people would be out of work. He was not satisfied that that was so. One was very definitely told that those stations had a limited number of hours over which they could work; they would, therefore, not be able at any moment of the day to deal with traffic, and one of the essentials of a good telegraph system was to get rid of the messages as soon as they were handed in. There was, of course, a very large commercial field for deferred work, and obviously a system which cost a small amount to erect, and which would carry a very much larger load per day, could deal efficiently and economically with such a traffic.

Mr. Frank Gill said Senator Marconi had set a very high example in the way he had persevered along a very difficult line, and had apparently reached very fine results. It seemed to him that that was an example to every worker. Professor Fleming, he thought, had hit on an essential point. The advantages to be gained were not so much the saving in power, good as that might be, but the possibility of utilising more stations, because undoubtedly there was a difficulty in the ether being overcrowded. Another reason why too much attention should not be attached to the question of power was that if one guaranteed—and it was a question of guaranteeing—to send a light along, say, a mile distance, in signalling on many days of the year, a candle would be enough; but if one had always to send that light signal through the air, or whatever it might be, then one had to encounter fogs, and because of that changed condition the power must be increased. One could not always work with as small a power as one could on many days of the year.

Captain P. P. Eckersley said he had not seen the paper before he arrived, nor had he intended to speak, but he had heard Mr. Shaughnessy mention the British Broadcasting Company's broadcasts of the K.D.K.A. station, so he immediately decided to rise in defence of his organisation, which had probably broadcast more x's than any other organisation in the world. It was not for him to deal fully with the very illuminating address which Senator Marconi had delivered, nor with the extraordinary field that the short wave working opened up, but there was one point in which he was interested, and that point was the question of telephony. He wanted to get clear telephony, and the transatlantic broadcasts showed that certain distortions were continuously present. His company had continually asked the Americans to institute and put in an independent drive at their end, as they believed this would cure distortion. Apparently they had not done so, and he thought it would be of interest to everyone to know the particular measures adopted by Senator Marconi in order to obtain the pure telephony at night without distortion.

Looking to the future, there was no doubt of the value of short wave working; at present its application to broadcasting was not obvious.

Mr. B. Binyon said there were only two points which he desired to mention. One was that Senator Marconi had quoted the efficiency of the radiation aerial to be of the order of 80 per cent., and in the figure which had been given the over-all efficiency of the whole system was also shown to be about 75 per cent. He thought that indicated some extraordinary progress in the design of valve plant, to have such very small losses in the valves and adjacent circuits themselves. The other point which especially interested him was the fact that Senator Marconi attributed the rapid fluctuations in signal strength on the yacht at the Cape Verde Islands to fluctuations in the wave length itself, and said that had the wave lengths been more constant those very quick fluctuations would probably not have occurred. Of course, every broadcast listener knew the rapid fading effects on the wave length, which was not so very far out from the wave length which Senator Marconi was using; and he wondered whether those quick fluctuations were entirely attributable to small wave-length changes throwing the receiver out of tune with the transmitter, or were due to rapid attenuation effects of the wave itself. Perhaps the author would give some more information on that point.

Dr. J. Robinson said that the paper which had been read that afternoon was a milestone in the history of wireless. He quite agreed with some of the speakers that very often the best way to make progress was to go backwards. Senator Marconi had done that, as had already been pointed

out, by going from very long wave lengths right down to 100 metres. Work on longer wave lengths in directional wireless had led to the conclusion that what are called variations of bearings were to be explained by attributing them to the Heaviside layer. Certain doubts had now arisen as to whether there is any Heaviside layer, and attempts are being made by French engineers to determine experimentally whether there is such a layer; but it seemed to him that Senator Marconi's experiments confirmed its existence, owing to the fact that he got by night tremendous signal strength, and by day very small signal strength. In that connexion he wished to ask one question: What was the relative signal strength by night and day? If it took, say, 28 k.w. to communicate with Australia by night, what power would one require by day, and was it impossible to get through? Was the case of a searchlight in a fog and on a clear night a parallel case, or were the conditions such that one could get through by day by putting up the power of the wireless transmitter?

H. E. THE ITALIAN AMBASSADOR said that Senator Marconi had again made a most valuable contribution to the scientific knowledge of the world. Italy was proud to claim him as her son, but he had contributed so greatly to the culture and civilisation of the world that he must be regarded as the son of humanity.

THE CHAIRMAN said he had been immensely impressed with the possibilities of the new development which Senator Marconi had brought to light, and judging by what the other speakers had said that was a meeting of great importance, which would be regarded in the future as a landmark in wireless telegraphy.

SENATOR MARCONI, in reply, said Sir Henry Jackson had referred to some doubts he had had in regard to the waves going east or west to Australia. The waves did not like sunlight; they preferred to travel over a track which was in darkness. In the early morning the darkness extended over the Atlantic Ocean and the Pacific, and the reverse was the case in the evening. Therefore, the waves chose the track which happened to be the darkest. He was very glad Sir Henry Jackson was present, because his early work in wireless should not be forgotten. Although, for particular reasons, it was never published, he thought the Admiral was using short waves during his early experiments.

He wished to thank Professor Fleming very much for the kind things he had said, and to point out that it was very largely due to his invention of the thermionic valve and his researches on the original valves and the rectifying valves that it had been possible to invent the new transmitting valves which allowed the production of continuous oscillations and of short waves.

With regard to what Mr. Shaughnessy had said, he quite understood his question in regard to signal variations or fading. Those signal variations, as he had said, did take place, but over the distances to which he had been referring the variations were not so serious as to make it impossible to receive efficiently, even when signals were at their weakest. He had referred to the results obtained from the American station at Pittsburg. If he was not mistaken the transmission from Pittsburg was telephony, not telegraphy, and if Mr. Shaughnessy had been present at the tests which he (the speaker) had been carrying out, he would have found out that it was very much easier to get an efficient reception telegraphically than telephonically. Distortion affected telephony more than it affected telegraphy. Most of his results, except the radio telephony experiments with Australia, had been with radio telegraphy. He also wished to point out that when reflectors were employed at the transmitting end, the variations or fadings seemed to get much less than without a reflector. He was not quite certain why it was so, but the variations were less. Mr. Franklin had also noticed the same thing over shorter distances. He did not know the reason, but he thought there would be a much smaller variation of signals when reflectors were used. Perhaps in the future, when Mr. Shaughnessy was convinced, as he hoped to be able to prove, that the system was efficient, the day might come when the Post Office might make it compulsory, as Dr. Fleming had suggested; and then one would not be able to work anything else. The instances he had given were for reliable communication which could be obtained any day. On ships it was true that often 1,000 miles could be covered with the existing systems by day, but, as he was a great deal at sea—in the literal sense, his experience was that it was not very certain. He did not contemplate using more than 20 or 25 k.w. at any of the stations, although he thought it was as well to see that they could use 50 k.w. if necessary.

He thanked Mr. Gill for his remarks, and Captain Eckersley had also referred to fading. What he had said in reply to Mr. Shaughnessy would, he thought, answer Captain Eckersley. With telephony one noticed distortion or fading or the signals going off, or whatever it was, very much more than in telegraphy. In speaking to Australia it was not noticed much. It might be that the independent drive introduced by Mr. Franklin at that station, or some particular conditions in Australia, which he did not know of, made the reception fairly reliable.

In answer to Mr. Binyon, who had referred to the efficiency of radiation as being 80 per cent. and the radiation being very efficient, Senator Marconi said he had not made actual measurements himself but he took the figures given by Mr. Franklin subject to confirmation. If those figures were what Mr. Franklin believed them to be it was a very efficient station indeed, and it represented a very marked improvement in the design of wireless transmitters.

With regard to Dr. Robinson's remarks as to the variation of bearings, he really did not know to what extent the bearings of the received signals varied at distant stations. He had only been trying to ascertain the reliability of reception, and he did not know if the direction varied much or not; he thought it did not, but that had to be tested. In regard to the Heaviside layer, there was perhaps no Heaviside layer. He did not want it, especially if it shifted its position every time! With regard to the relative strength by night and by day, the signals by night were certainly enormously stronger than by day, and the indications were that in the middle of the day any practicable amount of power would not get through very long distances. He did not know, however, if by narrowing the beam or by the employment of other wave lengths it might not be possible to do great distances by day. At present, if there was a considerable distance of the track to be traversed by the waves under sunlight, especially if the sun was high, one could not get the waves through. He did not know, however, anything about that, except that it would appear to be very difficult indeed, if not impossible. to get messages to Australia by daytime so far as he had tried. He could not speak in regard to what might be achieved in the near future, when reflectors at both ends are in use.

In conclusion he wished to thank the Council of the Royal Society of Arts for the opportunity given to him of delivering his lecture, and Mr. Campbell Swinton for presiding, and for the remarks he had made in regard to his work; he wished to thank his audience also for their presence, and for the very kind way in which they had received him.

NOTES ON BOOKS.

Masters of Science and Invention. By Floyd L. Darrow. London: Chapman and Hall, Ltd. 10*s*. 6*d*. net.

Architects are apt to complain that the works, if not the names, of the great architects of the past are unknown to the general; doctors make a similar complaint about the masters of their craft; while men of science lament the world's apathy about the famous thinkers who have built up our knowledge of chemistry, physics and other great sciences. No doubt such ignorance is deplorable, and is partly due to the nature of our education, which has hitherto been inclined to stress the literary side at the expense of other branches of study. In the book before us Mr. Darrow has attempted to do something to cure the world's ignorance in respect of the masters of science and invention. He has given us short biographies of a great number of scientific thinkers from Galileo to Marconi, written in such language as to be intelligible to the merest layman, and outlining in a general way the trend of their discoveries, and showing the parts they played in developing scientific theory and discovering scientific facts. The reader who has assimilated this volume will not only be familiar with such names as Lavoisier, Scheele, Berzelius, Liebig, Mendeléeff and Agassiz, he will also have a very fair idea of the particular work which they carried out and of the difficulties they had to overcome in accomplishing it.

PYRETHRUM FLOWERS IN JAPAN.

Pyrethrum flowers are produced in Japan in the Wakayama and Hiroshima prefectures, by small farmers, who dry the flowers and pack them in straw bags. The growers, however have no knowledge of export business procedure, or of the English language, and consequently it is impossible to deal with them direct. According to a report by the United States Consul at Kobe, the dried flowers are purchased from the farmers by jobbers, who, in turn, sell to the exporters. These exporters inspect, re-dry, and re-pack the flowers into hard-pressed bales suitable for export, and are the only concerns having the facilities for conducting foreign trade.

The price of pyrethrum flowers in Japan is subject to a considerable amount of manipulation. The growers, jobbers, and exporters combine into guilds, whose only purpose is to maintain prices, and, owing to the short supply of pyrethrum flowers in the world, they have been fairly successful in their endeavours.

The following table gives the quantity and value of exports of this commodity from Japan in 1920-2:—

Years.	Pounds.	Yen.
1920	2,926,598	2,553,695
1921	1,127,687	551,549
1922	3,983,083	3,357,188

THE VERMILION INDUSTRY IN HONG KONG.

One of the oldest and best known of the Hong Kong industries is the manufacture of vermilion, which is used by the Chinese for making varnishes, for colouring candles and paper, and for stamping and writing purposes. The annual output in Hong Kong, says the United States Consul there, is estimated to be about 20,000 cases of 50 catties each (66⅔ pounds), the total value being approximately 1,800,000 Hong Kong dollars. Of the total output of 20,000 cases, about 10 per cent. is for local use, 10 per cent. for exportation to the United States and Europe, and 80 per cent. for exportation to Canton, Fatshan, and the neighbouring districts. The exports to the United States and Europe are small in consequence of the competition of coal-tar dyes, which are much cheaper.

There is only one grade of Chinese vermilion, made of a mixture of mercury and red sulphur in the proportion of 100 to 90; that is, 100 pounds of mercury to 90 pounds of red sulphur. The red sulphur employed is secured from the Provinces of South China.

About 20,000 flasks of mercury are annually used in the vermilion industry in Hong Kong.

The mercury is packed in steel flasks containing 75 pounds each and imported direct from Europe, chiefly from Italy and the United Kingdom. The former country supplies 65 per cent. and the latter 25 per cent., the remainder coming from Spain and Belgium."

JOHORE STRAITS CAUSEWAY.

The causeway across the Straits of Johore, connecting the island of Singapore with the mainland, was opened to goods traffic on September 17, and to passenger traffic on October 1, 1923. The ferry system in use for 14 years has been discontinued.

The Johore State railway was opened to traffic in 1909, and a car ferry service was established between Johore Bahru and Woodlands. Each of the ferry boats carried six goods waggons, and passengers were transferred by launches. When the traffic increased from 11,500 waggons in 1911 to 54,000 in 1917, it was decided that other means would have to be provided for its through movement. Construction of the causeway began in 1919. Its cost will be borne jointly by the Governments of the Federated Malay States, Johore, and the Straits Settlements.

When completed, writes the United States Vice-Consul at Singapore, the causeway will contain over 1,500,000 cubic yards of rubble. It is built in an average water depth of 46 feet at low tide. Its length will be 3,465 feet and its width on top will be 60 feet, carrying two railway tracks and a 26-foot roadway. A lock is provided for the passage of local craft, and a rolling lift bridge carries the railway and roadway across the lock. The moving part of this bridge weighs 570 tons and is operated by electricity.

CO-OPERATIVE SOCIETIES IN CHINA.

Co-operative societies in China are limited almost entirely to students' organisations in some of the larger universities, which are of little consequence in the economic life of the nation. Producers' and consumers' societies are virtually non-existent. Certain quasi-co-operative credit societies, however, are found.

According to the official "Commerce Reports," published by the United States Bureau of Foreign and Domestic Commerce, a foreign missionary in Shantung has organised a credit society, known as the Taipu Co-operative Credit Society, in certain Shantung towns. Each member must pay 10 silver dollars (approximately £1) in cash or by instalments. Loans may be raised from outside, with the society as guarantor. A member may borrow from the society if he can get another member as guarantor.

In seeking to provide protection against future famine in famine areas, the China International Relief Committee has recently drawn up a set of rules for the organisation of rural-credit societies in China. The committee promises to stand behind such societies provided they are carried on according to these rules and are under the supervision of the committee. No society has yet been formed on these lines, but surveys of the needs in different communities are being made.

There is an old Chinese institution resembling a co-operative credit society, which is merely called a "hui" or "society." It may consist of any number of people, usually 10, 20, or 30. Each member agrees to pay a fixed amount every month for so many months and the total amount thus collected is drawn for by lot. The duration of the society depends on the number of its members 10 months for 10 members, 12 months for 12 members, etc. When one member has drawn the money for one month he no longer takes part in the drawing. The member who draws first gets the use of the money in a lump sum without interest. The member who is unlucky enough to draw last gets back his 10 deposits without interest.

GENERAL NOTES.

Sisal Hemp Production in the Empire.—Sisal hemp is chiefly produced in Mexico, where the annual output is about 150,000 tons. More than nine-tenths of this goes to the United States, where it is employed for the manufacture of the binder twine used in harvesting the grain crops of the Western States. It is obvious, therefore, that European buyers must look to countries other than Mexico for adequate supplies of the fibre. A résumé of the present position of sisal hemp cultivation in the British Empire is given in the current issue of the *Bulletin* of the Imperial Institute. African sisal, produced in Tanganyika and Kenya Colony, is of excellent quality and large quantities come to this country. The Bahamas also grow the fibre on a fairly extensive scale, but the whole of their output is taken by the United States. No other country is at present producing large quantities of the fibre, but commercial supplies may be expected in the near future from Ceylon, Nyasaland, Gold Coast, Mauritius and Jamaica. Several other regions are well adapted to the crop and have extensive areas available for cultivation.

Yakutsk Fur Trade.—The approximate number of the various furs accumulated at Harbin during the 1922-23 trapping season, and sold and shipped from Harbin in the summer of 1923 were as follows: Squirrel, 700,000; ermine, 30,000; kolinsky, 2,000; red fox, 4,000; white fox, 20,000; gray fox, 500; silver fox, 30; sable, 400; and hare, 100,000. These furs, writes the United States Consul at Harbin, were for the most part shipped up the Lena River and overland to Irkutsk, thence by train to Moscow, where practically all of them were sold to London buyers.

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FRIDAY, AUGUST 1, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICES.

PRESENTATION OF THE SOCIETY'S ALBERT MEDAL TO H.R.H. THE PRINCE OF WALES.

The Council of the Royal Society of Arts attended at St. James's Palace, on July 25th, when Field Marshal H.R.H. the Duke of Connaught, K.G., President of the Society, presented the Society's Albert Medal for 1924 to H.R.H. the Prince of Wales, K.G., "in recognition of services rendered to Arts, Manufactures and Commerce as President of the British Empire Exhibition, and by his visits to the Dominions and India."

The members of the Council present were as follows:—Lord Askwith, K.C.B., K.C., D.C.L., (late Chairman of the Council), Senator G. Marconi, G.C.V.O. (Chairman of the Council), Lord Blyth (Chairman, Dominions and Colonies Section Committee), Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., Sir William Henry Davison, K.B.E., D.L., M.P., Sir Archibald Denny, Bt., LL.D., Mr. Peter MacIntyre Evans, M.A., LL.D., Sir Edward A. Gait, K.C.S.I., C.I.E. (Chairman, Indian Section Committee), Sir Robert A. Hadfield, Bt., D.Sc., F.R.S., Rear-Admiral James de Courcy Hamilton, M.V.O., Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Major Sir Humphrey Leggett, D.S.O., R.E., Colonel Sir Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I., Sir Philip Magnus, Bt., (Chairman, Examinations Committee). Sir George Sutton, Bt., Mr. Carmichael Thomas, Dr. J. A. Voelcker, M.A., Ph.D., and Sir Frank Warner, K.B.E., with Mr. G. K. Menzies, M.A., (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

They were introduced by Lord Askwith.

Lieut.-Colonel Sir Malcolm Murray, K.C.V.O., C.B., C.I.E., was in attendance on the Duke of Connaught.

COUNCIL.

A meeting of the Council was held on Monday, July 21st. Present:—

Lord Askwith, K.C.B., K.C., D.C.L., in the chair; Sir Frank Baines, C.V.O., C.B.E., Sir Thomas J. Bennett, C.I.E., Sir William H. Davison, K.B.E., D.L., M.P., Sir Archibald Denny, Bt., LL.D., Sir Edward A. Gait, K.C.S.I., C.I.E., Major Sir Humphrey Leggett, D.S.O., R.E., Sir Charles C. McLeod, Sir Philip Magnus, Bt., Senator Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., Sir George Sutton, Bt., Mr. Carmichael Thomas, Sir Frank Warner, K.B.E., and Sir Philip Watts, K.C.B., LL.D., F.R.S., with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

Senator Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., was elected Chairman of the Council for the year 1924-25.

The reports of the judges on the First Annual Competition of Industrial Designs were received.

The various Committees of the Council were re-appointed.

Suggestions for improving the *Journal* were considered and approved, the alterations in type, etc., to come into force in the next volume, which will start in November.

Certain alterations in the syllabuses of the Examinations were approved.

The arrangements for Lectures and Papers in 1924-25 were further considered.

Other formal business was transacted.

DOMINIONS AND COLONIES SECTION.

THURSDAY, JULY 24th, 1924; HON. W. ORMSBY-GORE, M.P., in the chair.

A paper on "Recent Developments in the Belgian Congo" was read by M. LOUIS FRANCK, G.C.V.O., Minister of the Belgian Colonies, 1918-24.

The paper and discussion will be published in a subsequent number of the *Journal*.

COMPETITION OF INDUSTRIAL DESIGNS.

The Exhibition of selected works submitted at the Society's Annual Competition of Industrial Designs is now being held, by the courtesy of the Director, in the North Court of the Victoria and Albert Museum, South Kensington, S.W., and will remain open until Saturday, August 30th. The designs exhibited are divided into the following classes: Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. The Exhibition is open to the public free daily from 10 a.m. to 5 p.m., and on Thursdays and Saturdays from 10 a.m. to 9 p.m.

The Reports of the Judges, including the awards of prizes, have now been received, and it is hoped to publish them in the *Journal* at an early date.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, MAY 27TH, 1924.

DR. J. W. EVANS, C.B.E., D.Sc., F.R.S., President of the Geological Society, in the chair.

THE CHAIRMAN, in introducing the lecturer, Prof. C. Gilbert Cullis, said there had been great interest evinced in the economic wealth of Cyprus for the last 5,000 or 6,000 years; he believed it had been a topic of conversation among those interested in metallurgy in Egypt thousands of years ago. At any rate a great deal of the copper from Cyprus had found its way to Egypt. The mines had also been worked in Greek and Roman times. In the last 40 or 50 years Austrians and Frenchmen had reported on the mineral wealth of Cyprus. When the island became a British Dominion it had been up to us to ascertain exactly what its mineral wealth was, and he was very proud that he had had the honour of recommending for that purpose Prof. Cullis and his brilliant young assistant, Mr. Edge. That his choice had been justified he thought the audience would agree after they had heard the paper.

The paper read was:—

A SKETCH OF THE GEOLOGY AND MINERAL RESOURCES OF CYPRUS.

By C. GILBERT CULLIS, D.Sc., M.I.M.M.

(Professor of Economic Mineralogy, Royal School of Mines, London).

Cyprus first came under British administration—if we except its occupation for a brief period in 1191 by Richard Cœur-de-Lion—in 1878; but on the terms then negotiated by Lord Beaconsfield it remained Ottoman territory and its inhabitants Ottoman subjects. The entry of the Turks into the War, on the side of the Central Empires, resulted in the annulment of that agreement, and since November 5th, 1914, the island has been a British Crown Colony.

The acquisition of this new dependency carries with it new responsibilities, and, in order that the well-being of its people may be promoted, a knowledge of the island's potentialities has become more than ever desirable. It is with the object of calling attention to its mineral possibilities that this sketch has been prepared.

In 1921 the writer was commissioned by H.M. Colonial Office to report upon the cupriferous deposits of the island, and he and his colleague, Mr. A. Broughton Edge, carried out the necessary field investigation in the autumn of that year. The indications of copper mineralisation are widely distributed, and practically all of them were inspected. A unique opportunity was thus afforded of exploring the island and of acquiring a first-hand acquaintance with its general geology and mineral resources.

The examination was necessarily incomplete, however, and it should be understood that, except as regards the copper deposits, the sketch is largely based upon the work of earlier observers, notably Gaudry, Unger and Kotschy, Russell, Bergeat, Reid, and Bellamy. The geological map by Bellamy and the paper by that author and Jukes-Browne were specially helpful, and it is desired to make full acknowledgment of the information obtained from these and other publications.

The geology and economic minerals of Cyprus are remarkably varied. Both sedimentary and igneous rocks are present, the former occupying about four-fifths of the island, the latter one-fifth. The sedimentary rocks range from Cretaceous to Recent; the igneous are generally supposed to belong to one period, viz., Miocene. Assuming this to be so the stratigraphical succession is as follows:—

Pleistocene
Pliocene
Igneous Rocks
Idalian Series (mainly Miocene)
Kythrean Series (mainly Oligocene)
Trypanian Series (Eocene and Cretaceous).

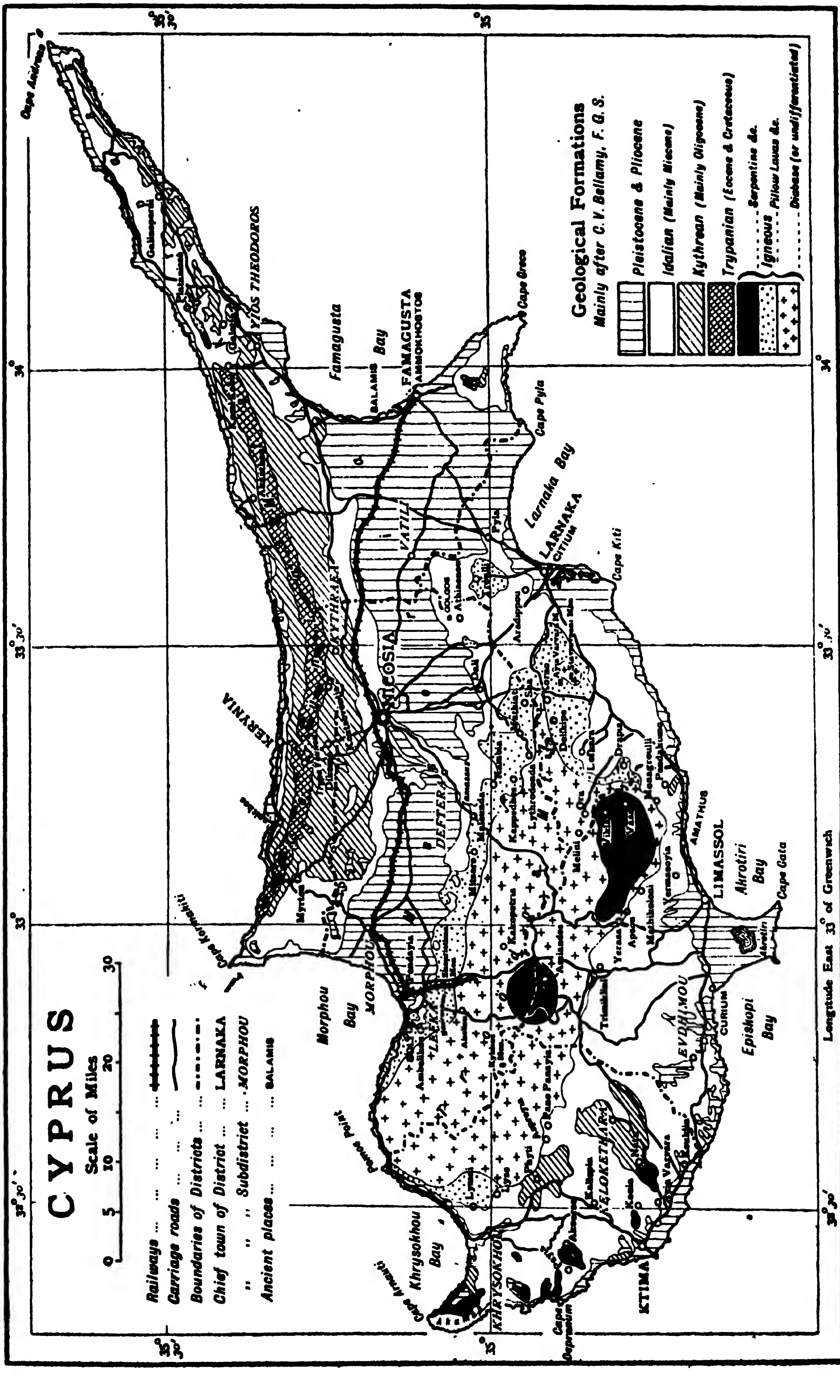

FIG. 1.—Geological Map of Cyprus.

These several groups will be considered in turn, the rocks and general geology of each being dealt with first, the materials of economic interest afterwards.

Trypanian Series.

Geology.

The oldest sedimentary rocks are those forming the ridge of the Kyrenia Mountains. They consist of massive limestones and dolomites. Numerous igneous intrusions are present in them, and by the heat of these, as also by compression, the limestones have been largely changed into marble.

Their outcrop forms a narrow band, nearly 60 miles long, but not more than three across, running parallel with and close to the coast. To the west it ends on the shore near Cape Kormakiti. Its eastern termination is at the base of the Karpass Peninsula. The middle line of the outcrop is marked by a chain of peaks, often over 3,000 feet in height, and the slopes down to the sea and to the central plain, or Mesoria, are very steep (Fig. 2).

The beds are folded into a sharp anticline the limbs of which plunge beneath the newer strata to north and south. Eastwards the anticline pitches under the later rocks of the Karpass. The folding has probably been accompanied by faulting and these dual disturbances make the determination of thickness uncertain. It has been estimated at 5,000 to 6,000 feet.

No identifiable fossils have been found in these strata. Their age is, therefore, unknown; but from analogy with fossiliferous rocks on the mainland, and especially with the Hippuritic Limestone of Greece, they are generally regarded as Cretaceous.

Limestones of a similar kind, and probably referable to the same series, occur at a few localities in the south-west of the island, where they appear as inliers exposed by the erosion of overlying formations. These small outcrops may indicate the summit of a buried anticline south of the Troödos Mountains corresponding with the Kyrenia anticline north of them. In this southern area, again, the limestones have been invaded and altered by igneous intrusions.

At the western end of the Kyrenia Mountains thin-bedded shaly limestones flank the Trypanian beds on both sides of the range. These are known as the Lapithos Beds and have not been recognised in other parts of the island. Certain foraminiferal shells have been found in them from which an Eocene age has been inferred. Their relations to adjacent formations are difficult to make out. Bergeat thought them discordant with the massive limestones, but Bellamy and Jukes-Browne have reported them to be in conformable relationship and to denote an unbroken Cretaceous-Eocene sequence. On the map (Fig. 1) they are included with the Trypanian.

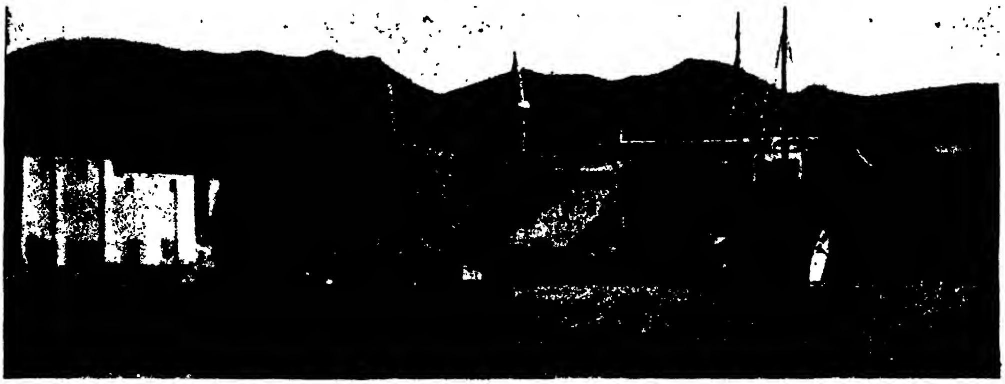

Fig. 2.—Kyrenia Harbour; Kyrenia Mountains in background.

Mineral Deposits.

Marble.—The Trypanian is principally notable for its ornamental marbles. They are specially developed where the limestones have been crushed and recrystallised, or intruded by igneous rocks. White, coloured, veined, and brecciated marbles are represented, and along the 60 miles of the range the available quantities must be very large. Bellamy states that some years ago specimens of the best types were sent to Naples to be polished and were

submitted to marble experts, who reported them to be of excellent quality.

They are not quarried at present, but appear to have been worked extensively in early times. In many of the ancient and mediæval buildings marbles have been used, practically all of which can be matched in place. Gaudry thought these stones did not originate in Cyprus, but the existence of identical material *in situ*, and the improbability that heavy building material would be imported to a land so well provided by nature, favour the view that the stones employed were of native origin. The possibility of establishing a marble industry in Cyprus might well be considered by those interested in the development of its resources.

Lime and Clay.—The limestones burn to an excellent lime and are quarried for this purpose at several places. The best lime is said to be obtained in the neighbourhood of Dikomo, at Kazaphani near Kyrenia, and just outside Kythrea. The series also yields a plastic clay which occurs in pockets and fissures in the rocks, and is probably a residual material left as the limestones have been dissolved at the surface. In the villages it is used for roof construction, a thick layer being spread over the foundation of brushwood with which the flat-topped houses are thatched.

Petroleum.—Among the limestones a black variety has been recorded which becomes white when heated. Gaudry considered the colour due to bitumen. It is probably the occurrence of material of this kind that has given rise to the belief that petroleum exists in the Kyrenia range, and has led to a certain amount of prospecting for oil. One of the districts where these supposed seepages have been reported is that of Akanthou, and some years before the war Dr. Arthur Wade made an examination of the ground. No developments ensued, however, and it is assumed that the evidence obtained was not considered favourable.

Licenses have at various times been issued to oil-mining firms, some of good standing, for exploration in the island, and investigations have been made, but as no serious work seems ever to have been begun, and permits have been allowed to lapse, it is inferred that no indications of the existence of petroleum or petroliferous rocks on an economic scale have yet been found.

Kythrean Series.

Geology.

Succeeding the Trypanian is the Kythrean formation, a series, perhaps 1,500 feet thick, of buff-coloured gritty sandstones and sandy shales, with breccias and conglomerates below and grey-green marls above. The basal rocks contain fragments from the underlying Lapithos beds and Trypanian limestones, indicating an unconformable junction and a break of some importance. The green marls, on the other hand, pass conformably up into the overlying formation.

This series is best developed near the Kyrenia Mountains which it flanks on either side. The northern outcrop is narrow, but the southern is much broader and, indeed, provides the finest exposure of these beds in the island. Beyond the eastern end of the Trynanian ridge the two outcrops merge and continue as a single band, beneath a broken cover of newer rocks, along the whole length of the Karpass.

Besides its principal development north of the Mesoria the Kythrean has a subordinate development south of the Troödos range, especially in the Paphos District. Here it occurs as inliers, sometimes with Trypanian cores. Of these the largest occur in the vicinity of Kelokethara, around Phyti, between Peyia and Akoursou, and north of Neokhorion in the Akamas Peninsula. There is also a small inlier at Pendakomo in the Limassol District. In this southern region the Kythrean beds are often associated with igneous rocks.

No fossils except a few Foraminifera have been found in the Kythrean rocks so that their age has not been determined on a palæontological basis. They are conformably overlain, however, by beds which are definitely Miocene, and cover unconformably others which are Cretaceous or Eocene, and on this evidence are taken to be of Upper Eocene or of Oligocene age. This conclusion is supported by a comparison with similar strata of known date in neighbouring parts of Europe.

Mineral Deposits.

The Kythrean strata contain little of economic value. Certain of the sandstones are suitable for building-stone, but they are not much used because better material occurs among the limestones of the newer formations. Slabs of some size suitable

FIG. 3.—Well bedded chalks and chalky marls of Idalian Series near Yerasa.

for paving stones, etc., may be obtained in certain places where the sandstones are well bedded and are not folded.

IDALIAN SERIES.

GEOLOGY.

Resting on the Kythrean is a conspicuous formation made up of three members the combined outcrop of which occupies nearly half the island. The included strata constitute the Idalian Series. The middle member, 1,200 to 1,500 feet thick, consists of snow-white well-bedded chalks and chalk marls with layers of flint and chert. These pass down into grey or green marls, about 400 feet thick, containing important deposits of gypsum. The marls are supposed to shade conformably into the Kythrean series below. Above, the chalks are succeeded by rough cream-coloured shelly and coralline limestones.

This triple sheet may once have covered the whole island. Though extensively eroded it still has a wide distribution wrapping round both mountain ranges. Its principal outcrop lies south of the Troödos range and sweeps across from Akamas to Larnaca. It is also strongly developed in the Mesoria, but here it is much hidden by later deposits. From the Mesoria it stretches along the Karpass and thence swings back as a narrow band between the Kyrenia range and the coast.

Over large areas these beds have a flat or nearly flat lie (Fig. 3). This is especially the case in the great southern outcrop and in the district of Dali. Around the Kyrenia hills steep dips prevail and are an expression of the severe folding this part of the island has undergone. All round the Troödos Mountains, too, the strata are highly inclined or contorted. This has generally been regarded as a consequence of igneous intrusion, but alternatively may be due to crushing of the soft sediments against a resistant igneous buttress.

Fossils, though not numerous, are sufficent to prove the beds to be mainly Miocene. They can be correlated with similar Miocene rocks in Syria. The basal gypsiferous marls may perhaps be Oligocene, and if so would be better included with the Kythrean. In like manner some of the highest shelly limestones may possibly be Pliocene. But the central white chalk, the most abundant and characteristic sedimentary formation in Cyprus, is certainly Miocene.

MINERAL DEPOSITS.

Gypsum.—Of all the sedimentary formations the Idalian are the most important from an economic point of view. The most valuable product is gypsum. This is found as crystallised selenite, as massive rock-gypsum and alabaster, and also in a peculiar laminated condition. Its distribution, coextensive with that of the basal marls, is very wide, workable deposits occurring in all the administrative Districts.

Aradippou and Pyla (Larnaca), Yermasoyia (Limassol), Patriki and Galinoporni (Famagusta), Hagia Paraskevi, Yerolakko and Lefka (Nicosia), Myrtou (Kyrenia), and Letymbou and Kallepia (Paphos) are notable localities. There are others where gypsum is either obtained on a small scale, or is known to occur in workable quantities. Only those deposits which are most favourably circumstanced are at present exploited.

The mineral is quarried. It is exported in the raw state, and is also burnt to plaster of Paris, *e.g.*, at Larnaca and Limassol, the finished product being shipped abroad or absorbed in the island. The quantities and value of the exports for a number of years are given below.

Exports of Cyprus Gypsum.

Year.	Long Tons	Gold (Currency)
1915	2,635	£1,575
1916	3,147	£1,814
1917	490	£319
1918	452	£581
1919	2,970	£5,222
1920	7,114	£10,451
1921	8,881	£9,827

Some of the alabaster, *e.g.*, that from Pyla, is suitable for decorative purposes, and a certain amount has been so used in some of the larger Cyprus buildings. It should also be well adapted to the modern utilisation for electric light shades.

The laminated mineral is extensively quarried, under the name of "marmaras," for interior paving slabs. It cleaves into plates of various thicknesses, which can be sawn to any size or shape and dressed to a smooth surface. It makes an admirable material for floors, stairs, shelves, sills, etc., and is widely used throughout the island in houses and public buildings of all classes. Indeed, it is so serviceable for indoor constructional work that, if better known, a demand for it outside Cyprus might arise.

Umber.—Where the Idalian marls are in contact with the igneous rocks, especially the volcanics, they often assume a dark brown colour and acquire value as the pigment "terra umbra." The umber zone may be as much as 10 or 15 feet thick. The material is soft and earthy, and is usually of a rich coffee-brown colour, although lighter and darker shades occur. Powdered it makes a pigment which in tint and covering power ranks among the best natural umbers known.

The total length of outcrop of the Idalian-igneous contact approximates to 150 miles. Whether the umbers are developed along the whole of this is not known, but the length of contact that is certainly umber-bearing is very great, and the available supplies must be practically inexhaustible.

The umber is of particularly fine quality in the volcanic inlier of Troulli, and it is from this area that most of the present supplies are obtained. The shipping port is Larnaca. Bellamy refers also to production near Limassol. The location of quarries in these two districts has been determined by considerations of transport; equally good material occurs at other places, which might become centres of production if the need arose.

The mining is of a most primitive kind, and seems both inefficient and wasteful. A pit is sunk above the igneous-sedimentary contact, which, after the umber has been extracted to a shallow depth, is abandoned and another opened near-by. The work is done by small groups of Cypriotes who, having no adequate appliances, are unable to follow the mineral to depth. They operate on a contract which covers the mining of the mineral and its delivery to the concessionaire or his agent at port. Some of the mineral is calcined to "burnt umber," but most of it is shipped as "raw umber." It goes principally to Italy and the United States. In 1917 the amount exported was 1,881 tons, valued at £3,746. Cyprus umber, in view of its excellence and the low cost at which it can be produced, should be much more in demand. If given greater publicity it should find a much wider market.

The umbers seem to be modified marls, the modification consisting in their impregnation with iron and manganese. Away from the contact they pass insensibly into snow-white chalks. By many they have been considered to be due to contact-metamorphism brought about by igneous intrusion. This is possible, but there is evidence that they often, perhaps only, occur in association with lavas. This seems to preclude ordinary contact-action, and it is probable that they have been formed by the passage of iron and manganese solutions from these igneous rocks into the later-deposited chalky sediments.

Manganese.—The umber is sometimes of a very dark colour, almost black. This is due to oxide of manganese which occurs as sooty films on the fracture planes of

the rock, or as nodules and spongy masses embedded in the matrix. These may be seen at many places. They are well shown in the rich umbers of Apsou, near the Amyrou Monastery.

When in place the manganese is distributed in relatively small amount through the body of the umber, but at outcrop, where the rock has been exposed to long-continued erosion, the nodules are concentrated on the surface or in the soil. In such cases large areas are covered with the ore, which most commonly appears as scattered pellets resembling the droppings of sheep or goats. These are often seen along the junction of the marls and volcanics, *e.g.*, on the eastern slopes of Phoucassa Hill, near the Skouriotissa Mine, and near Aradiou, south-west of Deftera. Considerable quantities can be quickly collected from the ground, and the mineral, as proved by an analysis of material from the former locality which showed 52.18 per cent. of manganese, is of good grade.

Another locality where manganese ore of similar origin occurs is about two miles west of Platanisso in the Karpass. Here irregular spongy masses, consisting of pyrolusite and psilomelane, rest upon volcanic rocks. The latter rocks form an inlier surrounded by Idalian marls, and presumably erosion of the umbers has left the residual manganese upon the surface of the underlying eruptive.

Unfortunately these showings have not been found on a scale promising commercial possibilities, but they prove that manganese occurs in the island, a fact that should not be overlooked by prospectors. They are also of interest as accounting for the high manganese content of the old slags that are so abundant in connexion with the once-worked copper deposits. It would appear that the umber, or possibly the manganese collected from it, was used as a flux in these ancient metallurgical operations.

Zinc.—North of Yerasa zinc blende with a little iron and copper pyrites in a mass composed of siderite, dolomite, etc., has been found in close association with gabbro. The carbonate body may represent a patch of Idalian limestone altered by the gabbro; if so the zinc and copper have probably originated from the gabbro also. The occurrence is noteworthy as proving the existence of zinc, and as suggesting that copper mineralisation in the island may be connected with the plutonic intrusions. It is not yet known whether the zinc is present in workable quantities.

FIG. 4.—Underside of "dhoukani" with trimmed flints in place.

Flint, Lime, "Athienou Stone."—Chalcedonic silica in various forms is abundant in the Idalian. Flints and bedded cherts are plentiful in the chalks; and at contact with igneous rocks silicification has locally taken place, resulting in the formation of jaspers. These siliceous stones are used in making the "dhoukani" or agricultural implement which is universally employed for threshing. (Fig. 4). It consists of a long wide board one end of which is bent up for the attachment of traces. Loaded with one or two seated riders it is dragged by mules or oxen over the threshing-floor on which the reaped corn has been spread (Fig. 5). The flints, suitably trimmed to a sharp edge, are embedded lengthways in rows on the underside of the board and serve to beat out the grain and cut up the straw. Later, by throwing the mixture into the wind, the grain is winnowed from the chopped straw, the latter being used for making sun-dried bricks. This primitive practice has been in use for hundreds, perhaps thousands, of years, and the suggestion has been made that the "dhoukani" may be a survival of the Neolithic age.

Many of the jaspers are of bright colour and might have some value as gem-stones. Probably in the past, when the gem varieties of silica were more prized than now, they were so used, and the traditional fame of Cyprus for its precious stones may to this extent be based upon fact.

The purer limestones, especially the shelly and coral limestones which overlie the

FIG. 5.—"Dhoukani" in use on threshing floor near Lefka.

chalky beds, yield a fair lime, though they are not as suitable for this purpose as the limestones of the Kyrenia range. At several places, notably in the isolated limestone hills east and west of Lefka, *e.g.*, Ambelikou and Koronia, quarries have been opened up for the stone, and kilns, fired with wood-fuel constructed near at hand. These are not in operation continuously but are only used as demand may arise.

East of Dali in the neighbourhood of Athienou the Idalian beds assume a lithological character which gives them special local value. Though continuing soft and earthy they lose their highly stratified structure and snow-white colour, and become thick-bedded, homogeneous, and grey. In this state they yield large blocks of soft freestone which can be cut and dressed in any direction and carved to any shape. This freestone is used for making stone vessels such as troughs, sinks, and bowls for dyeing and washing. The stone stands heat well and is also cut into fire-bricks for grates, stoves, ovens, and furnaces. It is rather deficient in strength and articles made from it tend to be massive and rather clumsy. They are not suitable for export, but being very serviceable are widely used within the island.

IGNEOUS ROCKS.

GEOLOGY.

Igneous rocks play an important part in Cyprus geology. Their principal development is in the Troödos Mountains (Fig. 6). The igneous outcrop here is 50 to 60 miles long by 15 to 20 broad, and has an area of about 1,000 square miles. Besides this main outcrop there are smaller ones to east and west, at Troulli and between Kouklia and Akamas. North of the Mesoria others occur in the Kyrenia Mountains and the Karpass. These scattered masses probably originated from a common source, and it is possible that the whole island is underlain at no great depth by an igneous foundation.

The rocks are remarkably varied. Basic and ultra-basic types largely predominate, but intermediate and even acid types are represented. The bodies are mainly in-

FIG. 6.—View up Evrykhou valley with Troödos Mountains in distance.

trusive, but effusive masses occur on a considerable scale.

Of plutonic rocks gabbros, pyroxenites, peridotites, and serpentines are the commonest; syenite is also recorded from one locality. Among hypabyssal types, diabase predominates, but quartz porphyry and pegmatite occur rarely. The volcanic materials include andesite and basalt, pillow-lavas of andesitic affinities being particularly abundant; trachyte and rhyolite have also been reported. With these lavas volcanic fragmentals in the form of tuffs and breccias are sometimes associated. Of the various rock-types three stand out as of special quantitative importance, *viz.*, diabase, serpentine, and pillow-lavas.

In the map (Fig. 1) the heterogeneity of the igneous areas is expressed by differences of shading, and an attempt is made to suggest the geographical distribution of the three rock-types just specified. The boundaries are rough approximations only, and on a detailed survey would doubtless need substantial modification; but this attempt at differentiation, based as it is upon observation in the field, is thought to be better than a representation of the igneous rocks as of one kind only. Such a differentiation is desirable, because the diabase areas are of little economic significance, while those of serpentine and pillow-lava are of considerable importance.

augite has been changed to hornblende, *i.e.*, it is a uralite-diabase; other secondary minerals, which it contains locally, are chlorite, epidote, zeolites, quartz, and metallic sulphides—a suite suggestive of alteration by hydrothermal solutions.

The limits of the diabase are difficult to discover, and the boundaries between it and associated rocks have never been mapped in detail. In two areas at least it contains intrusive, or differentiated, masses of gabbro, serpentine, etc., and elsewhere, *e.g.*, near Ora and Stavrovouni, it is pierced by small veins of granitic pegmatite. It is surrounded in the foot-hills by a girdle of volcanic rocks, often several miles across. Whether these rocks everywhere intervene between the diabase and sedimentaries is not known. Bergeat states that diabase is never seen in contact with sedimentary formations. Possibly on the map, therefore, the ring of volcanics should be continuous, and not broken as shown. Time did not permit of the whole of this margin being seen, and the volcanics are only inserted where actually observed.

Serpentine, &c.—Serpentine is the most abundant plutonic rock, but it rarely occurs alone. It is usually accompanied by related rocks of the gabbro, pyroxenite, and peridotite families. Some of these latter are remarkably fresh, and are indeed the least altered igneous rocks in the island.

FIG. 7.—Kykkou Monastery and surroundings, showing typical scenery of the diabase hills.

Diabase.—This rock is confined to the central parts of the Troödos range. Forming the mountain groups of Khorteri-Kykkou, Adelphi-Papoutsa-Machera, and Stavrovouni it constitutes an enormous mass which in bulk greatly exceeds that of any other igneous rock-type (Fig. 7). It is a fine-grained ophitic rock in which the original

These plutonic complexes occur in isolated masses intrusive into various formations. Thus, in the Troödos range there are at least two masses, one on Troödos itself, and another between Yerasa and Drapia, which are intrusions, or differentiates, in diabase. Between Kouklia and Akamas there are others that have been intruded

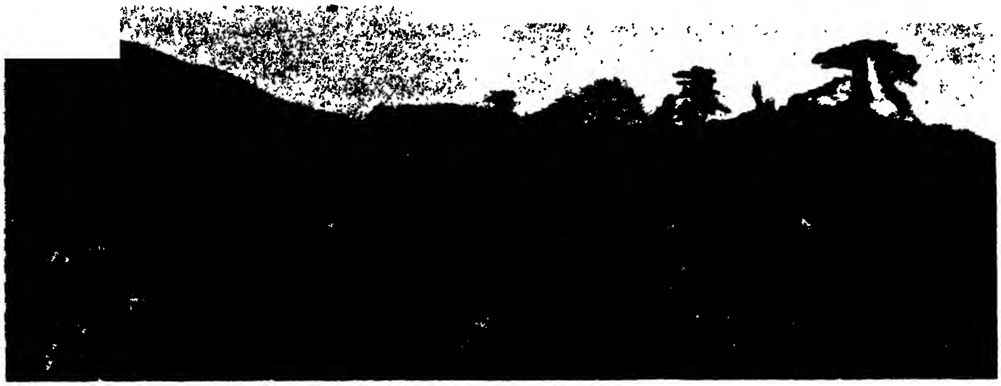

FIG. 8.—Scenery characteristic of the serpentine between Amiandos and Troödos.

into sediments belonging to the Trypanian, Kythrean, and Idalian formations. With some of these occurrences volcanic rocks are associated, and apparently these, too, have been intruded by the plutonics. Similar conditions obtain between Eptakomi and Platanisso in the Karpass. Several plutonic masses are also intrusively enclosed in the Trypanian limestones of the Kyrenia range. Nowhere in the island, however, are Pliocene beds invaded.

There is evidence that the various plutonic rock-types are arranged in zones around a central nucleus, much as in the intrusive bosses of the Urals in which there is a passage outwards from peridotites through pyroxenites to gabbros. The Russian masses are important as yielding platinum, chromite, and asbestos, these economic minerals being confined to the peridotites and serpentines, and it is significant that two of these minerals occur in equivalent rocks in Cyprus.

This zonal arrangement is known to hold good in the great circular boss on Troödos. The centre is peridotite changing, or changed, to serpentine, and carrying chromite and asbestos. This core is followed by enstatite peridotite, then by a true pyroxenite of bronzite and diallage, and finally by gabbro, which is in contact on its outer side with the surrounding diabase. These outer zones are barren.

Pillow-lavas.—The volcanic rocks have their chief development along the northern edge of the Troödos massif, where they form a belt of relatively low foot-hills between the

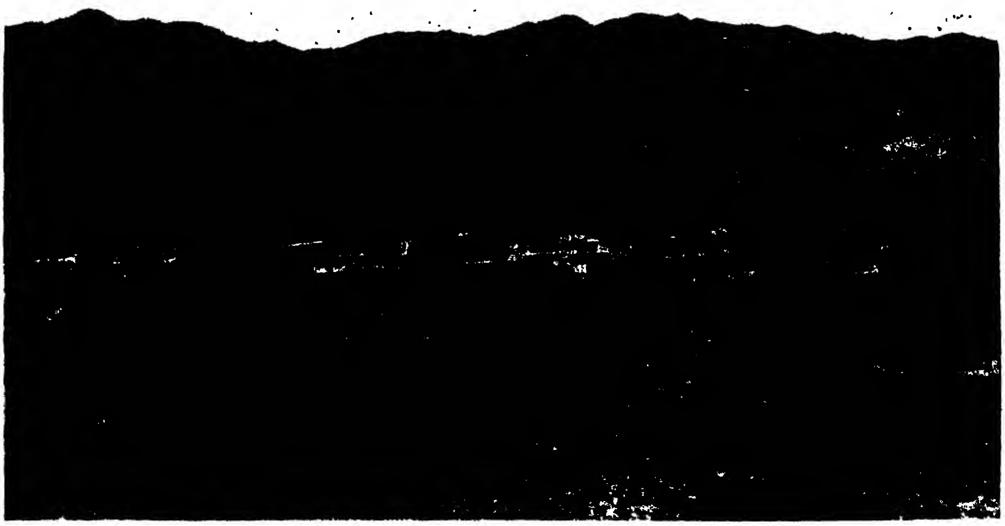

FIG. 9.—Kambia; volcanic rocks covered in foreground by Idalian marls, and succeeded in distance by diabase.

sedimentary rocks of the Mesoria and the diabase of the mountains (Fig. 9). Westward this belt can be traced round the Tillyrian coast to the shores of Khrysokhou Bay and thence inland, past Lymni Mine, to Lyso or beyond. Eastward, it swings by Stavrovouni, which diabase mass it completely surrounds, and returning along the southern margin of the range can be followed to Lefkara and possibly as far as Drapia and Asgata. It reappears between Trimiklini and Perapedhi, and may perhaps extend all along this margin, in which case it would entirely encircle the Troödos Mountains. Rocks of the same kind occur at Troulli, at various points in the south-west, and in the Karpass.

larians and sponge spicules have been shown to make up 17 per cent. of this material (see reference 4). The pillow-structure, chill-margins, and presence of marine organisms between the pillows, denote a submarine origin for these lavas. That volcanic action occasionally became sub-aerial is proved by the occurrence of lavas with unmistakable ropy surfaces. These are well seen at Pendakomo. Further evidence of volcanic action is afforded by the occurrence of bedded tuffs, volcanic breccias, etc. Such rocks occur just north of Trimiklini and at other places.

The volcanic rocks, being contemporaneous with the Idalian marls, are of Miocene age, and it is probable that the intrusive rocks associated with them, *viz.*, the diabase and

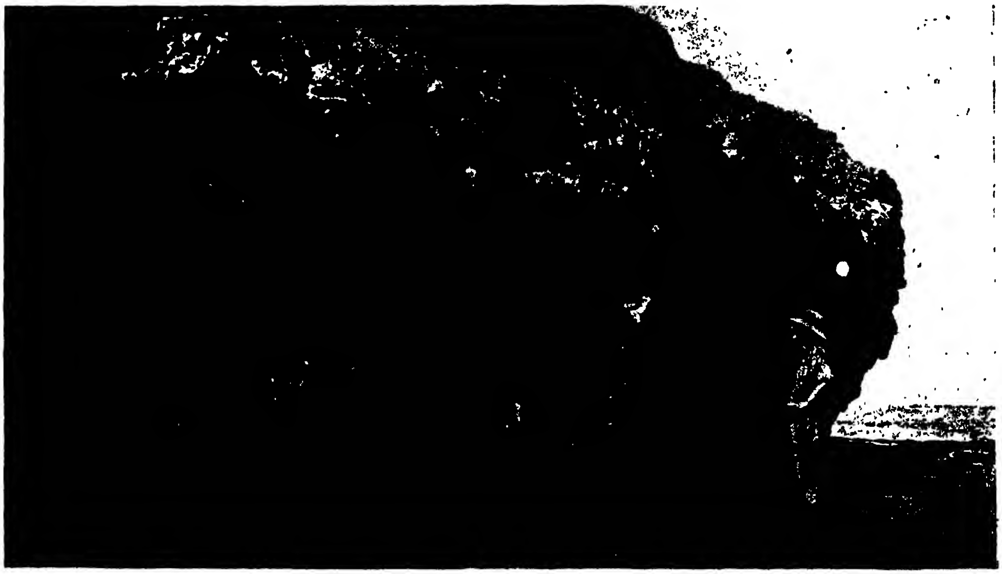

FIG. 10.—Lava with pillow-structure, south shore of Morphou Bay.

the plutonics, are of the same general age.

The rocks are mainly andesitic, but basic variants of basaltic type also occur. Many of them are highly scoriaceous, the vesicles generally containing zeolites, &c. These amygdaloids are so abundant as to be a characteristic of Cyprus geology. Another feature they constantly exhibit is a fine pillow-structure (Fig. 10). Glassy chill-margins often surround the pillows, *e.g.*, at Koronia, and in these the vesicles are small; internally the rock has a normal stony look and the steam-holes are much larger. This is distinctive of pillow-lavas elsewhere. Between the pillows marine sedimentary matter occurs, and at one locality, *viz.*, Lymni, radio-

MINERAL DEPOSITS.

The igneous formations differ as to their economic minerals. The diabase is the least important in this respect. It has a limited use as road-metal, yields small quantities of clay from which rough pottery, tiles, etc., are made, and here and there is feebly mineralised with copper. The plutonic and volcanic rocks are more important. The serpentines contain asbestos, chromite, and magnesite. The pillow-lavas are the principal depository of the copper-bearing ores. It was from them that copper was won in the past, and it is to them that

we must look for such supplies as the island may yield in the future; to-day these ores have an added value for the manufacture of sulphuric acid.

Copper.—From the evidence of old mining operations and ancient slags, the winning of copper was an important industry in Roman, and even in Phœnician, times. Especially large slag heaps are seen at Phoucassa Hill and Mavrovouni near Lefka, and it is here that the ancient mines of Soli are supposed to have been situated. Other large accumulations lie south of Deftera, *e.g.*, at Mitsero and around Lythrodonda, and these are thought to mark the old mining field of Tamassus. Many other localities could be mentioned, and a map showing the places where slags occur would prove how widely the centres of this old industry were spread.

Near the larger slag heaps there are usually surface indications of mineralisation which mark the deposits from which the copper ore was mined. These are in the form of iron-stained patches, which in tints of yellow, red, brown and purple, are conspicuous, even from a distance, and in the brilliant Cyprus sunshine look like oriental carpets laid out on the hill-sides. Since Roman times, and until the late years of last century, no serious interest was taken in these evidences of mineral, and no copper mining was attempted. But about 1880 prospecting was begun, and has been continued intermittently ever since.

The earliest of this modern exploratory work was done at Lymni near Polis in the Paphos District, where there are impressive gossans and abundant signs of ancient mining and smelting. This work has proved the existence of disseminated mineralisation, but no important body of high-grade ore has yet been discovered in the Lymni Mine or concession.

Later, in 1913, the examination of another showy outcrop, on the slopes of Phoucassa Hill, was begun. This lies just above the Skouriotissa Monastery, the name of which refers to the great heaps of Phœnician and Roman scoria which lie at the foot of the hill (Fig. 11). The work was undertaken by an American prospector who had drillers with him, and the ground was systematically tested by boring. Ore was struck in July, 1914. A mining lease was obtained, and the Cyprus Mines Corporation was formed in 1915 to develop the property. The exploration was continued and resulted in the location of an ore-body estimated to contain six million tons of high-grade ore—the first contribution in modern times to the proved copper resources of the island.

The Skouriotissa Mine has been opened up by the above mentioned company to exploit this body. It is within a few miles of the shores of Morphou Bay, with which it is connected by an extension of the Government railway. From the shore near Pendayia a jetty has been built from which the ore can be loaded into lighters for transhipment to vessels lying out in deeper

FIG. 11.—Ancient slags, Phœnician in foreground, Roman farther back; Phoucassa Hill (Skouriotissa Mine).

water. Direct connexion with Nicosia and the port of Famagusta is also available by the main line, which passes close to the mine.

Phoucassa Hill, 1,300 feet above the sea, is a sedimentary outlier on volcanic rocks. At the top there is coral limestone, perhaps Idalian but probably Pliocene. This is underlain by typical Idalian chalks and marls. As the igneous contact is neared these pass into umbers. In the mine the umbers rest upon ore, but elsewhere upon the volcanics, which are amygdaloidal lavas with well-marked pillow-structure.

The ore lies between the umber and the pillow-lava, but within the latter. The ore-body is a nearly horizontal slightly concave sheet with an irregular border; in form it may be compared with an oak-leaf with its underside downwards. The length is about 1,500 feet and breadth 750 feet. It is thickest in the middle, about 125 feet, and thins to nothing at the margin. Except along a narrow strip on the hillside, where it outcrops, it lies beneath a sedimentary cover roughly 150 to 250 feet thick. The general level is 800 to 1,000 feet above the sea, and is well above the surrounding country. This facilitates mining.

The ore is cupreous pyrites containing about 50 per cent. sulphur and 2 per cent. copper; it is practically free from arsenic. Much of it is soft and porous and in mining yields a large proportion of fines. The structure is often like that of the volcanic rock, the mass consisting of packed ellipsoids of the same shape and size as the pillows of the lava. This appearance and the finding of residual lava in the cores of the ellipsoids, suggest an origin by replacement. According to this hypothesis, ore-bearing solutions ascending from igneous rocks below were impounded by the impervious marls and, spreading beneath this cover, effected replacement of lava by ore, the pillow-structure of the lava being retained and a porous texture developed as a result of volume reduction. This genetic theory is not accepted by all who have examined the mine. Mr. F. A. W. Thomae, who regards the eruptive as intrusive, believes that the ore is magmatic and essentially a matte injection.

In association with the pyrites mass are smaller bodies of two secondary substances which may prove of value as by-products. These are "devil's mud" and native sulphur. "Devil's mud" is a peculiar material, consisting largely of soluble sulphates, which is found in parts of the mine not far from the outcrop. It contains considerable values in precious metals; a sample gave 2.12 oz. gold and 12.96 oz. silver to the ton. The available quantities are not yet known, but a large body has been proved on the 820 ft. level. At a higher level, *viz.*, the 915 ft., is the "sulphur stope," where a mass of native sulphur has been opened up. Figures supplied gave sulphur 87 per cent., silver 2.02 oz., and gold 0.33 oz. per ton. "Devil's mud" occurs on this level also, in layers between the sulphur and pyrites, and here it is richer than below. Samples showed from 5 to 8 oz. gold and up to 20 oz. silver to the ton. Both of these by-products have originated from the reduction of ferric sulphate to ferrous, and the consequent liberation of sulphur and deposition of precious metals.

The Skouriotissa deposit is the only one so far proved by modern prospecting; but surface signs of mineralisation, at least as marked as at Phoucassa, are known at many other places, and it is possible that important deposits of this type may exist in connexion with some of these. In all cases the showings have the same geological occurrence as at Skouriotissa, *i.e.*, they lie in the pillow-lava at or near its contact with the Idalian marls, and the line of this contact marks the position where the search for additional bodies should be made. Thus, west of Skouriotissa promising indications occur at Mavrovouni and near Akoliou. East of it there are several others, the most impressive being those of Mitsero, Kambia, Kappedhes, Mathiati, Sha, and Delikipo. Along the southern contact evidences of mineralisation are less numerous; those at Lymni are the best known, but others occur at Asproyia, Pano Panayia, Yerasa, and Asgata. Outside the Troödos massif further indications appear in the volcanic inliers of Troulli near Larnaca, and of Platanisso in the Karpass.

Many of these localities yielded ore in ancient times, as is proved by old workings and slags; and within the last few years prospecting permits have been issued for the most promising, and exploratory work is being, or has been, done upon them. If investigations such as led to the discovery of the Skouriotissa mass were carried out, other bodies could hardly fail to be disclosed. Prospectors have not made sufficient use of the facts now known as to

the geological occurrence of the ore, or of systematic boring. The only deposit yet proved was located by this latter method and drilling at geologically selected points should be more fully employed.

While massive ore of shipping grade has only been found at Skouriotissa, disseminated ore has been proved at several places, *e.g.*, Lymni, Mavrovouni, Delikipo, etc., and the possibility of mining this and leaching it for copper on the spot, or even, in cases having a favourable topographical lie, of leaching it *in situ*, is worthy of consideration.

Besides these sulphur-copper ores in the pillow-lavas straight copper ores occur, on a small scale, in the diabase. These are mostly found in the mountainous parts of the Troödos range. They have been proved at Kykkou in the west, Stavrovouni in the east, and Melini, Mathikoloni, Monagroulli, etc., in the central region.

At some of these localities no attempt at mining or even exploration has ever been made; at others a little prospecting has been done but in no case with satisfactory results. The mineralisation is in ill-defined shear-zones in the diabase. The principal ore-mineral is chalcopyrite, but at outcrop malachite, azurite, cuprite, native copper, &c., have sometimes been formed by oxidation. The best showing is on Stavrovouni Mountain, a few hundred feet down from the Monastery, where scattered streaks and stringers of copper pyrites are seen in the igneous rock; but the mineralisation is probably too erratic and the position of the prospect near the top of this steep conical mountain too unfavourable for profitable mining. The copper deposits of this class are unpromising, and under existing conditions are of no economic importance.

Iron.—The gossans of the pyritic masses in the pillow-lavas sometimes contain brown iron ore of quite good quality and, in the case of the larger "blows," in fair quantities. Much of it is of a rich yellow or brown colour and possibly could be exploited for ochre if not for iron ore. Small quantities of magnetite and specular hematite also occur in the island, notably on the northern slopes of Stavrovouni about midway between the Stavrovouni and Ayia Varvara Monasteries. Here in the bed of a stream close to the track a considerable body of mixed magnetite and hematite is associated with a pegmatitic rock, both pegmatite and ore being enclosed in diabase. Specular hematite is also said to occur in diabase on a hill called Panayirka, near Monagroulli.

Chromium.—More important are some of the occurrences of chrome iron ore. This mineral appears in the basic plutonics at several places, *e.g.*, on Troödos Mountain, at Trooditissa, up behind Yerasa, at Konia near Ktima, and between Ayia Varvara and Nata. It is a constituent of peridotite or serpentine, and all areas where these rocks occur should be carefully prospected for it. As a rule the mineral is scattered too sparsely through the rock for economic recovery; but it is a notoriously pockety ore, and wherever disseminations occur, exploitable masses may also be found.

Recently, by laborious quarrying and hand dressing, 12 tons of ore were obtained in the Paphos District and sent to England. The places of origin and chromic oxide content are shown below. Most of the ore was good, but the cost of production was prohibitive.

Chrome Ore from Paphos.

Locality.	Cr_2O_3 per cent.
75 bags from Konia	46.02
30 ,, ,, ,,	50.39
73 ,, Kissonergha	39.04
65 ,, Ayia Varvara	54.38

Still more recently, prospecting on the northern slopes of Tröodos has resulted in the discovesy of deposits estimated to contain on the surface, or at very shallow depths, several thousand tons of chromite. A private company with substantial financial backing is now commencing actively to exploit these deposits, and it is hoped that considerable shipments will be made during this season. The accompanying analyses show the quality of the ore. It is probable that other deposits exist in the island.

Chrome Ore from Troödos.
(Dried at 100° C.)

	1	2	3	4	5
Chrome oxide	48.90	51.88	50.80	51.65	49.74
Iron ..	13.47	12.75	12.48	12.36	12.33
Silica ..	4.43	1.93	2.25	2.15	3.26
Magnesia ..	16.79	16.65	16.50	16.95	17.22

The similarity of the peridotites and serpentines which carry the chromite, and of the pyroxenites and gabbros associated with them, to the igneous rocks with chromite, asbestos, and platinum in the Urals, has been mentioned. The rocks of Cyprus are known to contain chromite and asbestos, and

the possibility of their being platiniferous naturally arises. While the fact that no platinum has ever been recorded tells against the probability of its occurrence, the geology and paragenesis are peculiarly favourable, and the gravels of streams which flow from serpentine masses might well be tested for this precious metal.

Associated with the serpentine masses of Greece, especially where they are intrusive in the Cretaceous limestones, are the well-known nickel-silicate ores. It is always possible that some of the serpentine intrusions of Cyprus, *e.g.*, those occurring in the Trypanian limestones of the Kyrenia Mountains, might prove on careful examination to be similarly nickeliferous.

The only actively producing field is that of Amiandos, on the eastern slopes of the mountain at an elevation of 5,000 feet. Here surface mining and milling have been proceeding for many years (Fig. 12). In 1907 a concession was granted to the Cyprian Mining Co., Ltd., of Trieste to mine asbestos in the Troödos Forest for ninety-nine years; but in 1919 this concession was cancelled, and a mining lease was granted to a local syndicate. In 1921 property covering six square miles was acquired by the present holders, the Cyprus Asbestos Co., Ltd., by whom it is being worked.

The Amiandos fibre is short and for many years this prevented its utilisation; but

FIG. 12.—Separation of long-fibred asbestos from matrix by hand cobbing, Amiandos-on-Troödos. (Photo. by Foscolo, Cyprus.)

with the introduction of uses for short-fibre mineral a demand for it arose, and in normal times it can command a good market. The asbestos-bearing serpentine, though containing only a small percentage of recoverable fibre, is practically unlimited in amount. Prior to acquisition by the present owners the dressing plant was small and not very efficient, and the finished product, packed into 6-foot sacks, had to be transported in mule carts over a winding road for a distance of nearly 40 miles to Limassol for shipment to Europe. An up-to-date installation, designed for an ultimate capacity of 12,000 tons per annum, has now been erected, and an 18-mile aerial ropeway constructed from the mines to the sea near Limassol.

Asbestos.—Asbestos occurs in Cyprus in both its forms, *viz.*, serpentine-asbestos (chrysotile) and amphibole-asbestos. They are found in the basic plutonic rocks, especially the serpentines. The ancients perhaps obtained mineral from these deposits, as they did from those of Italy, for cremation-sheets, lamp-wicks, etc. If so, the longer fibred amphibole-asbestos was probably the variety mined. In modern times only the chrysotile variety has been exploited.

The principal deposits so far located are in the serpentine core of the Troödos boss. In this the asbestos has a wide distribution, being found not only at Amiandos but also in the districts of Kakopetria and Troöditissa, where prospecting licenses have been held by Bell's United Asbestos Co., Ltd., of London, and by various Cypriotes.

The exports of asbestos from Cyprus,

wholly from the Amiandos field, are given below for the years 1913 to 1921.

Cyprus Asbestos.
(Exports in long tons)

1913	—	1,168	1918	—	228
1914	—	246	1919	—	1,331
1915	—	1,099	1920	—	896
1916	—	1,291	1921	—	897
1917	—	1,069	1922	—	

Amphibole-asbestos has been found at numerous points. It occurs in the large plutonic boss which lies in the diabase south of Ora, notable localities being Vikla, Vasa, and Apsou; and outside the Troödos range it has been observed in the small plutonic masses of the Paphos District, *e.g.*, near Episkopi. Licenses to prospect for asbestos at these and other places have been issued.

Some of the mineral, *e.g.*, that from Vikla and Vasa, shows fibre six inches and more in length. It is not of spinning quality, however, is liable to be harsh, and is not as uniformly distributed through the rock as the chrysotile-asbestos. Moreover, the technical applications of this variety being restricted, there is little demand for it at remunerative prices. Up to the present no regular mining of it has been attempted.

Magnesite.—Besides chromite and asbestos the serpentines contain magnesite. The only place where this mineral is known in quantities having commercial possibilities is in the Akamas Peninsula. Here serpentine is largely developed and in places is covered by limestone. The magnesite is found at or near the contact, and appears to have been formed by the action of carbonated waters from the limestones upon the serpentine.

The best material is high up on the ridge of the promontory, near Kephalovrysia, (Fig. 13) the flat top of the ridge being of limestone, the slopes serpentine. At various points irregular veins and stockworks and concretionary nodules of magnesite are to be seen in the igneous rock, the contents ranging from massive snow-white mineral to mixtures with serpentine in all proportions. An analysis of a sample is given below. It will be seen that the proportion of carbonate of lime in this particular material is rather high.

Fig. 13.—Magnesite prospect (Cyprus Magnesite Ltd.) Akamas Peninsula.

Cyprus Magnesite from Akamas.

Magnesium carbonate ..	94.00	per cent.
Carbonate of lime ..	4.55	„
Silica and insoluble matter	.98	„
Iron oxide and Alumina..	.18	„
Moisture	.18	„
	99.89	

From excavations which have been made in this district the available quantity of massive and disseminated mineral appears to be large. No regular production had taken place in 1921, but the area merits investigation as a possible new magnesite centre. It is within a few miles of the coast and is well placed for transport by gravity to sea-level.

Recently the principal prospects have been acquired by Cyprus Magnesite, Ltd., of London, and are being vigorously prospected. A road for camel transport has been made to the nearest suitable point on the shore of Khrysokhou Bay, and a line for a projected aerial ropeway has been surveyed. Stocks of mineral are being accumulated both at the prospects and on the coast. Samples properly taken from these stocks, and analysed in Glasgow in March, 1924, show the composition tabulated below.

Akamas Magnesite (Cyprus Magnesite, Ltd.)
(dried at 100°C.)

SiO_2	.14%	.24%	2.38%
Fe_2O_3	tr.	tr.	tr.
Al_2O_3	tr.	.30%	5.58%
CaO	2.73%	3.23%	5.92%
MgO	46.07%	45.10%	37.57%
CO_2	51.41%	51.27%	49.08%
	100.35	100.14	100.53
$MgCO_3$	96.74%	94.71%	78.90%

Alum.—At Lefka and Lefkara the soil is said to be impregnated with impure sulphate of aluminium. It has probably been formed by the action of sulphuric acid, resulting from pyrites oxidation, upon clay. It appears on the surface as an efflorescence after rain and, Bellamy says, is collected and used for washing clothes. From their impurity and limited quantity it is hardly likely that the deposits could have any substantial importance.

"*Terre verte.*"—In certain parts of the island a green chlorite-like substance is found among the volcanic rocks, which has value as a pigment. Its use probably dates back to very early times. It is of a fine blue-green tint, is soft and homogeneous, and grinds to a smooth powder of good permanent colour. From the sub-joined analysis, quoted from Bellamy, it is clear that the mineral is not a true chlorite. The composition is similar to that of glauconite or celadonite; probably it is referable to the latter species.

"Terre Verte," Cyprus.

Silica	52.50
Ferrous oxide	26.44
Potash	15.72
Magnesia	0.84
Moisture	4.50

The chief district for it is that of Malounda, about 15 miles south-west of Nicosia. The volcanic rocks are here cut by columnar-jointed basaltic dykes (Fig. 14). The mineral occurs in steam-holes and cracks in these rocks, and also loose on the ground where it has been set free by weathering

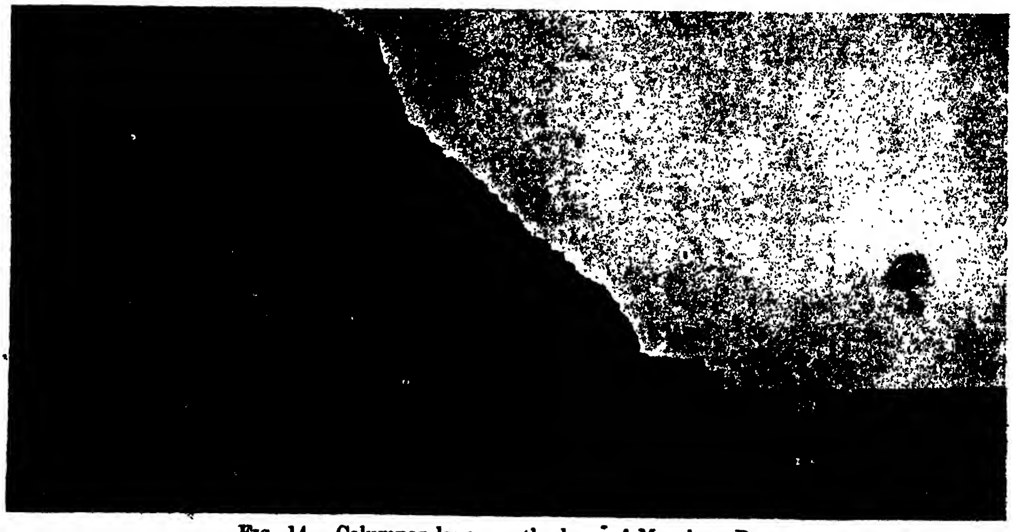

FIG. 14.—Columnar lava, south shore of Morphou Bay.

No definite deposit is developed, and there is no organised mining of the substance. It is collected by the inhabitants and sold to agents in touch with consumers. Some years ago there was a fairly regular export, principally to Italy. Green earth is a mineral pigment for which there seems to be a fair demand, and it is likely that if the existence and quality of the Cyprus material were better known, a more constant market might be created and a more regular output developed. Indeed, in its remarkable deposits of umber, ochre, and "terre verte," the island would appear to possess the raw materials for a useful industry in mineral paints.

Clay.—By weathering the igneous rocks yield residual clays, which are well suited to the manufacture of earthenware, rough pottery, &c. They are principally found on the lower igneous ground, especially in the valley bottoms. Deposits of such material occur at Galata and Phini, north and south respectively of Troödos Mountain, and at Korno, north-west of Stavrovouni Mountain. The two former are on diabase, the last on volcanic rocks. The clays are much used, either on the spot or at works in the larger towns, for making water chatties, wine-and oil-jars—some of very large size—earthenware cups for the primitive water-wheels, roofing tiles, bricks, &c.

Bellamy also records in the southern mountains "extensive deposits of puzzolana" presumably of like origin, which "possesses the virtue of rendering common lime hydraulic."

Road-Metal.—The diabase, if not too decomposed, makes excellent road-metal. Not only is it hard enough to withstand abrasion, but, having a fine felted grain, and containing as it does sufficient chlorite to act as a bond for the harder minerals, it has the additional quality of toughness, which preserves it from crushing under impact. It is used in the construction and maintenance of the well-engineered mountain roads such as those connecting the Troödos camp with Nicosia and Limassol. These are among the best in the island, largely because metalled with this stone. The roads near the large towns, and on the lower ground generally, are rarely so good, the difficulty and cost of obtaining diabase for them, except where certain igneous conglomerates referred to later provide it, leading to the employment of inferior local materials.

The suggestion has been made that the old slags might prove to have some value. They contain both copper and manganese, and it has been thought that one or both of these metals might be profitably recovered from them. A consideration of their composition shows that this is out of the question. But some of them, more particularly the Roman, which are as fresh as when first dumped, would make admirable ballast for railway construction. The material lies loose upon the surface and is already broken: it would therefore be cheap. It is physically strong, packs well, drains dry, and does not encourage the growth of weeds. It is so little affected by sun, rain, and frost as to be practically indestructible. In the south of Spain, where similar slags abound, they have long been used for metalling railway tracks, and with most satisfactory results. If and when a reconstruction or an extension of the Cyprus railway is undertaken, the slags might be of some value in connexion with this work. They should also be of use for ordinary road-making and have been so employed to some extent. But being sharp, brittle, and dusty they are better adapted for foundations than for the actual road surface.

Pliocene and Pleistocene.

Geology.

The sedimentary rocks of later date than the Idalian belong to two series—Pliocene

Fig. 15.—Flat-topped hills (Pliocene) of dissected plateau, Mesorian Plain.

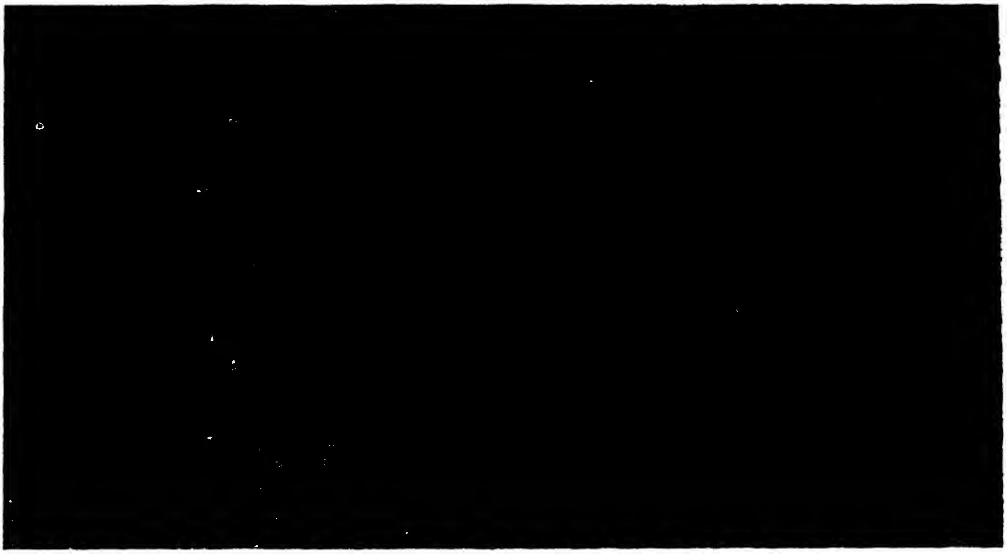

FIG. 16.—False-bedded shelly sands (Pliocene or Pleistocene) near Lapathos.

and Pleistocene. They are difficult to separate, largely owing to the fact that the Pleistocene beds have been in the main derived from the erosion of the Pliocene. On the geological map, because of this difficulty, they are indicated as a single formation.

During the Pliocene epoch the present mountain masses formed two islands, and the Pliocene beds occupy areas, in the central plain and around the coast, which were at that time submerged beneath a shallow sea. The rocks are principally shelly limestones and marls, but conglomerates containing pebbles and boulders of the igneous rocks are also common. Such conglomerates are of interest in proving that all the igneous rocks of the island are of pre-Pliocene age.

The Pliocene strata are fossiliferous; foraminiferal, echinoidal, and molluscan remains are abundant. They prove the age and marine origin of the beds and indicate a fauna similar to that of the present Mediterranean. Gaudry inferred from them that two divisions of the Pliocene should be recognised. Later observers have not found reason to question this view.

The Older Pliocene he estimated at about 200 feet thick; it is best developed in the Karpass and appears to pass conformably into the underlying Miocene. The Newer Pliocene, 50 to 150 feet thick, has a wider range; it covers much of the Mesoria, extends to Cape Pyla, and it also occurs in the Akrotiri promontory and along the coastal strip between Kouklia and Ktima. The beds are unconformable to underlying formations.

The Pleistocene deposits include both marine and terrestrial accumulations. They are confined to the present coast-line and to mountain slopes, river courses, limestone caverns, etc. The marine deposits are represented by the materials of raised beaches, coastal terraces, and sand dunes, the terrestrial by surface screes and conglomerates, alluvial sands and gravels, and cave earths.

The rocks consist of loose or slightly consolidated calcareous sandstones or shelly limestones, together with pebble beds, conglomerates, and breccias in which the fragments are of limestone, flint, igneous rock, etc. Travertine and calcareous tufa are abundant, and large smooth surfaces of this veneer are often seen where calcareous waters have issued from limestone hills. The cave-deposits are of special interest because of the peculiar mammalian remains they have yielded to the researches of Forsyth Major and Miss Bate. Pigmy elephant and hippopotamus were discovered, indicating the existence in Cyprus, as in Malta, of a highly specialised fauna of African affinities at no very remote period.

MINERAL DEPOSITS.

The economic materials from these newest rocks are by no means unimportant; they include building-stone, road-metal, and salt.

Building-stone.—The visitor cannot fail to be impressed by the architecture and by the material of many fine buildings in Cyprus. These include temples, castles, palaces, cathedrals, churches, monasteries, and fortifications in various states of preservation, besides modern structures such as bridges and municipal buildings. Many of the edifices are of great antiquity and all testify to the durability of the stone employed.

The finest building-stones in the island occur in these formations; the best coming from the newer Pliocene. They are principally calcareous freestones; but sandstones are also quarried. The rocks are usually of a warm yellow or buff colour, but some are almost as light as our own Portland or Bath stones. Others are darker and range from pale to dark brown; these, besides being less pleasing, are generally softer and less durable.

The quarries are distributed widely, and good stone is procurable in all the Districts. The most productive quarries are those favourably placed as regards the large towns. Thus, excellent sandstone is worked just west of Kyrenia and south-east of Nicosia; and limestones at Ayia Phyla north of Limassol, at a number of points round Famagusta, and at Ktima.

Road-metal.—The igneous pebbles and boulders of the coarse conglomerates serve a useful purpose in providing excellent material for road making. The pebbles are peculiarly hard and tough, only such igneous rocks having survived in the conglomerates as were capable of withstanding exposure and abrasion. Most of them are diabase, but fine and coarse gabbro and other rocks are not uncommon. They have been derived from the igneous complex of the Troödos Mountains. Natural processes have broken down and sorted these rocks, and transported them to distant localities where no other material suitable for road-metal occurs, and it is this circumstance that gives the conglomerates their special value.

The pebbles are collected from the surface or from stream-courses, where the beds have been disintegrated. They are dumped at convenient points along the main roads and are reduced to macadam size either by hand or by a portable crusher driven by an oil engine (Fig. 17).

Salt.—The Pleistocene formations have a special interest because it is from basins in them that the inhabitants obtain their supplies of salt. The deposits are formed by the drying up of salt-lakes which lie south-east of Larnaca and Limassol. At both places the lakes occupy depressions in areas of flat low ground which within comparatively recent times were covered by the sea, lagoons having been converted into lakes by the growth of intervening bars of sand.

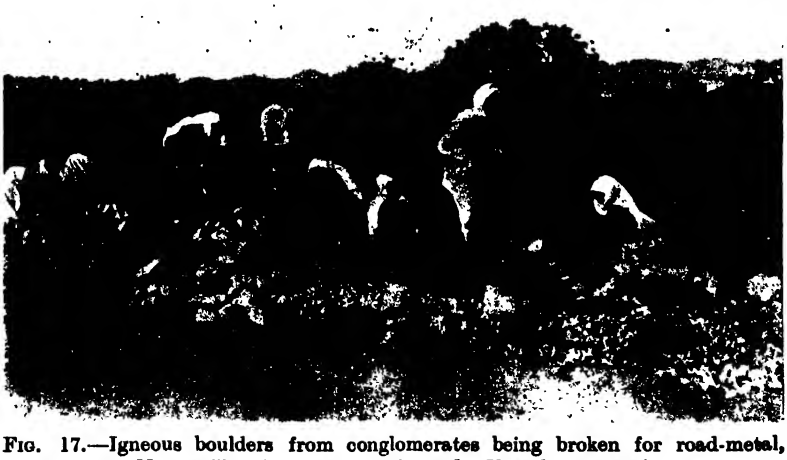

FIG. 17.—Igneous boulders from conglomerates being broken for road-metal, Nicosia-Troödos road. (Photo. by Foscolo, Cyprus.)

The Larnaca salt-lake is the more important, and is one of the most interesting natural features in the island. Its shore is irregular and has a circuit of some ten miles, but its area is only about two square

miles. The lake is separated from the sea by a low barrier of land only a few feet above the level of the highest tides. The bottom is 10 feet below sea-level. On its landward side it receives streams which flow down from hills of chalky limestone and igneous rock.

The belief among many Cypriotes is that the salts are brought into the lake by the streams, which are supposed to have dissolved them from the soil. But as Gaudry, Unger and Bellamy have shown, in genetic theories differing only in detail, they are derived from the sea. Indeed, to prevent the access of too much fresh water and consequent dilution, with the possibility that the summer heat would not cause solidification, a side channel has been constructed to conduct surplus land waters to the sea.

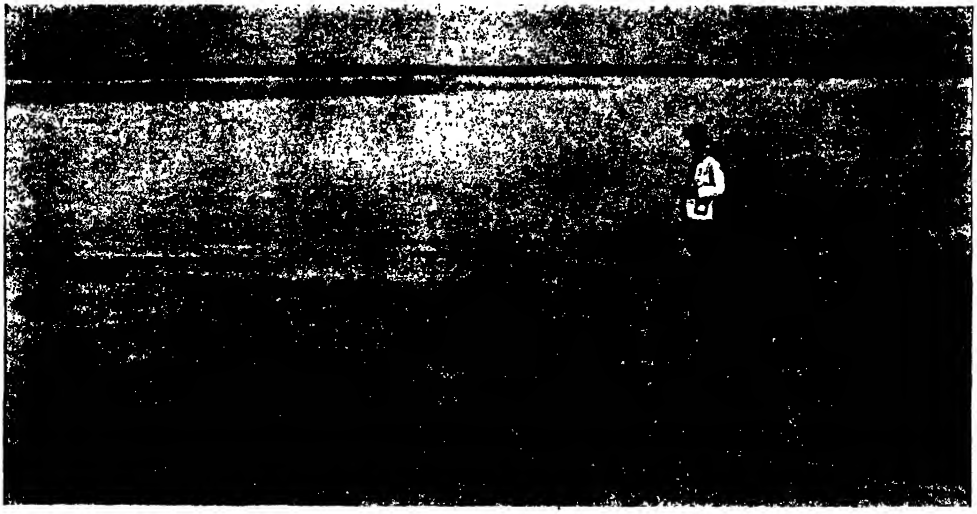

FIG. 18.—Larnaca Salt Lake in summer, showing surface of solid salt and low sand-bar towards sea.

During winter, when evaporation is at a minimum, sea-water percolates through the somewhat porous barrier and fills the lake. As the hot weather comes on, evaporation removes the water faster than percolation can introduce it, and eventually supersaturation and precipitation are brought about. By the end of the summer a cake of salt several inches thick, and on which it is possible to walk as upon ice, covers all but the middle of the lake (Fig. 18). In the following winter inundation again occurs and the supplies are thus regenerative.

The harvest begins in August. The salt is dug some way out, loaded into mule panniers, transported along a temporary causeway, and dumped high and dry on the bank. Some may also be sacked for distribution. The stock piles are built in the form of truncated pyramids, each being marked with the year of origin, and each containing many thousands of tons of salt of excellent quality (Fig. 19). In these the mineral sets and becomes hard and compact so that very little loss results from rain. Supplies are quarried from the piles as required.

Luke and Jardine (1920) give the cost of winning at about 3s. per ton, and state the annual crop to be 3,125 tons (2,500,000 okes of 2.8 lbs.). The salt is Government property and its sale a monopoly. Special guards and inspectors are appointed to watch the lakes and reserves, and to see that there is no illicit salt manufacture. The annual revenue derived is about £9,000.

Most of the mineral is consumed in the island, but there is some export, and if a demand from outside could be encouraged and markets established a very profitable export trade should be capable of development. The exports in 1919, 1920, and 1921 were severally 480, 615, and 885 long tons.

Complete desiccation of the lakes seems never to take place, and a considerable volume of mother-liquors remains. Apparently the composition of these has not been fully investigated. It would be well that the liquors should be analysed, since valuable salts of other metals than sodium, *e.g.*, potassium or magnesium, might exist in them in quantities worth extracting.

FIG. 19.—Salt stock-piles on shore of Salt Lake, Larnaca.

From what has been written above it will have been gathered that the geology and minerals of Cyprus are both interesting and important. They are, however, very imperfectly known. No systematic geological survey of the island has ever been made; neither have its mineral resources been thoroughly investigated. Moreover, its mining laws are antiquated and out of harmony with those of other parts of the Empire. Now that Cyprus is a Crown Colony it is highly desirable that work in these directions should be officially undertaken; and, in conclusion, the opinion is expressed that a new branch of the public service, having the functions and discharging the duties of a Geological Survey and Department of Mines, might with great advantage be added to the existing administrative machinery of the island.

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DISCUSSION.

THE CHAIRMAN (Dr. J. W. Evans) was sure the author of the paper had succeeded in imparting to the audience some of the enthusiasm which he had for Cyprus and all things appertaining to it, and he thought many present would now feel an interest in both its capabilities in the future and in its long and interesting past. Personally he should feel inclined to put back its metallurgical past rather longer than Prof. Cullis did. It was generally believed that our word "copper" came from Cyprus, because that was the original source of the metal. In Egypt copper had come into use before 3,000 B.C., and where should the Egyptians have got it from if it was not Cyprus? He would humbly submit that the Phœnicians had started to work at that date and had exported their metalliferous products to Egypt. The whole subject of past references to Cyprus was of the greatest possible interest. It would be easy to compile a whole chapter of different references to Cyprus by ancient writers. Theophrastus, the authority on minerals, stated that some of the "*kyanos*" used as blue paint came from Cyprus. Another variety was an artificial one made in Egypt out of copper, which no doubt also came from Cyprus. In Cyprus there was a river called the Amiandos, the modern form of *amiantos*, which meant "taintless," and the name was no doubt given to the river, on account of the pureness of its water. From the fact that the early mines of asbestos occurred near the source of that river, one of the ancient names for asbestos was *amiantos*. One could go on for a long time dealing with those ancient references to the mineral wealth of Cyprus. The author had referred to the use of the *dhoukani*,

the curious threshing sledge which had little fragments of flint stuck into the bottom of it. He had seen exactly the same thing in use in Spain, and curiously enough there the little flints were derived, just as they were in Cyprus, from Miocene limestones. There was no doubt at all that that same kind of sledge was used by the Romans. In Spanish it was called a *trillo*, a corruption of the Latin term "tribulum" applied to the same object. When one said that anybody had suffered great tribulations, one was inferring that his troubles were as bad as if he had had that horrible instrument drawn backwards and forwards over him!

He desired to ask the author whether clay was put upon the brushwood on the roofs of the houses in Cyprus in order to prevent fire: if not, what was the object of putting it there?

He had been very interested in the author's suggestions as to a further search for petroleum. The author proposed that the prospector should bore down through the gabbro and other igneous rocks, which might form a sort of roof over the more ancient sedimentary rocks, which might contain petroleum. Of course, it would be merely a sporting chance. There was one obvious criticism, namely, that igneous rocks came up from below, so that one could not expect to bore down through them to sedimentary rocks. He would suggest the answer to that was that it was by no means true that all igneous rocks came immediately from below; they were brought up at some place by earth movements, and then, much more often than not, they flowed sideways. So that a great fold of igneous rocks might have originally flowed in as a thick sheet, and then been raised up by earth movements to form an anticline.

Mr. F. A. W. Thomae, A.R.S.M., M.I.M.M., thought the lecture, delivered at the time of the British Empire Exhibition, was especially opportune, as so little was yet generally known about the latest acquisition to the Empire.

He had been interested in the genesis of pyrites deposits in Cyprus. It would be more accurate to say that he was inclined to believe rather than that he believed those deposits to be magmatic segregations. In the interesting discussion he had had with the author in the pages of the *Mining Magazine*, he had brought forward that theory of magmatic segregation as against replacement, because he thought it had several points which required serious consideration. There were, however, a number of geological questions involved, which very greatly contributed to the issue, and on which still a considerable amount of work was required before a definite pronouncement could be made on them. For instance, there were still questions about the true nature of the eruptive rock, its age, the age of the Idalian sediments, etc. There were also questions of observation, such as a careful study of the ore umber contact which was now being opened up in mining, and the eruptive sedimentary contact where there was no ore, and other points. So that it would be premature, he thought, to be convinced of the truth of either of those theories before more positive light could be thrown on those questions. So far, the opinions of different authorities who had studied them were by no means unanimous. He would like, however, to point out that as an aid to prospecting those two theories did not conflict. In either case the outer margin of the eruptive was the line of least resistance for the expulsion of the ore, whether as a segregation from the molten magma or as aqueous solution after its solidification. That was where the ore bodies had to be looked for, and a capping of sedimentaries was in either case essential for their preservation.

With regard to the age of the Idalian series, specimens collected by him from the top of Phoucassa Hill and submitted to the Jermyn Street Geological Survey had been reported on as indicating oligocene rather than pliocene age.

Mr. Louis N. Schoenfeld (Managing Director of Cyprus Magnesite, Ltd.), thought the author had not dwelt sufficiently on the mining resources of Cyprus, such as magnesite. A good deal of money had been spent recently in connexion with the production of magnesite and great developments had taken place. If any member of the audience would care to visit the offices of his company he could show them photographs which were quite as interesting as those which had been thrown on the screen that afternoon. He had recently had a letter from a gentleman in Sweden in connexion with his Company's ore in which he stated that the only trouble with regard to it was that it was too good. The development of the asbestos side of Cyprus was also rapidly going ahead, as he could testify from a recent visit to the island.

The Chairman enquired if the difficulty of finding those deposits to which the author had referred could not be solved by the process of electric prospecting.

Prof. Cullis, in reply, said the object of covering the brushwood on the roofs with clay was, he imagined, to keep out rain. In Cyprus the rainfall was in heavy showers rather than in a continuous downpour, and had not a serious effect on soft tenacious clay, especially after it had hardened. As to discovering ore-bodies by electric prospecting, he thought that was quite possible. A better type of ore-body than that found in Cyprus could not be desired for location by electric prospecting, because running into millions of tons concentrated into a small area. Another method which might be attempted was the gravity balance of Eötvos. He considered that Cyprus was a place where that method also might be employed effectively. He hoped that the day would arrive when scientific methods of prospecting would be used to assist the ordinary methods hitherto employed. That was one reason why he thought some official department might with advantage be established in Cyprus, which could foster and develop the

mineral industry, do all that was necessary to create new markets for Cyprus minerals, and also encourage more scientific methods of prospecting.

He was obliged to Mr. Thomae for the remarks he had made. He had intended to discuss the origin of the cupreous pyrites deposits, but he had been overweighted with material and had not had time to do so. He agreed with Mr. Thomae that enough was not yet known to enable one to be dogmatic. Mr Thomae's theory was an ingenious one, and might possibly hold, but his own hypothesis, namely, that the deposits had been formed by local replacement of the pillow-lavas, had a great deal to commend it, and he was inclined to adhere to it for the time being; he had, however, an open mind in the matter.

He had been interested in Mr. Schoenfelds' remarks. He could have dealt more fully with magnesite, but had had no time to do so. He did not know that the magnesite properties had been so much developed since he was there in 1921. When in the island he was much impressed by the magnesite occurrences. He had seen hundreds of tons of excellent magnesite collected on the surface waiting to find a buyer. The quality was also good, and he had not been able to understand why it was that the mineral could not be marketed. The magnesite deposits in Cyprus should be capable of important developments in the future.

He desired to take the present opportunity of expressing his thanks to Dr. Evans for having nominated him to go to Cyprus for the Colonial Office to report on its cupriferous deposits. It had proved a most interesting trip. He would also like to congratulate Dr. Evans on having done the same thing for other British Colonies. Dr. Evans had long been an adviser to the Colonial Office on the geological and mining possibilities of the Crown Colonies, and had sent investigators to several of those Colonies, with, he believed, very good results.

He concluded by thanking one of his colleagues, Mr. Grantham, for kind assistance rendered in making many of the lantern slides used in illustration of the lecture.

The Chairman, in proposing a vote of thanks to the reader of the paper, said the reason he had recommended Prof. Cullis for the work had been that he was quite sure he was the right man, and if the Colonial Office had as good work done in other parts of the Empire as they had had done in Cyprus, they would be very well satisfied. There were unthinking people in some of the Colonies who considered that a geological survey was of no value. They were perfectly willing to advocate the spending of money on agriculture, but when it came to geology they said it was merely ornamental and entirely useless. Geologists did not think so, and, as the author had hinted, it had been possible to show recently that geological surveys gave very important results.

NOTES ON BOOKS.

How to Paint Permanent Pictures. By Maximilian Toch. London: Scott, Greenwood and Son; New York: D. Van Nostrand and Co. 7*s*. 6*d*. net.

The cynic who asserts that it is no bad thing that many modern pictures are painted with materials that will perish before the painter—even he will scarcely refrain from regretting the havoc to be seen in most art galleries among works of great importance, caused by fading, darkening or cracking of paints. The subject is one that has troubled many—both painters themselves, collectors, and amateurs of art and general satisfaction was expressed at the announcement made a year or two ago that the Royal Academy had appointed a strong committee to investigate the whole subject. The matter is very complicated, involving the study of various chemical and physical problems hitherto but little explored, and it will probably be some considerable time before a report is issued. In the meantime artists who desire to see their pictures remain in sound condition would do well to study Mr. Toch's volume. It is the work of one who has had over thirty years' experience in the manufacture of pigments for all types of painting, and its object is to convey to the painter in simple langugage the reasons why certain materials should be used and others avoided.

Of the making of pigments there appears to be no end. To quote Mr. Toch: "One German manufacturer of considerable reputation mentions seventy-nine varieties of green; one hundred and twenty-three varieties of yellow; one hundred and seventy-nine of red; seventy-five of brown; seventy-nine of blue; thirty-two of black, and twelve of white. . . . All in all, one German catalogue contains five hundred and seventy nine varieties of colours." While some of these are good sound pigments. others deserve the worst that can be said of them. How is the unfortunate painter to know which is which? We commend Mr. Toch's suggestion that manufacturers of artists' materials should be legally compelled to label every tube of paint as to its permanence and chemical composition; but, until that is brought about, painters will find no surer guarantee against the premature decay of their works than in a careful study of this practical little handbook.

WOOL INDUSTRY OF CZECHO-SLOVAKIA.

The production of sheep's wool in Czecho-slovakia during 1923 is estimated by local authorities at 4,158,000 pounds, writes the United States Acting Commercial Attaché at Prague, a reduction of 145,000 pounds from the previous year. Since the major part of the home-grown wool is used in the home-manufacture of cloth, no accurate

figures are available. Those given are based on the estimated number of sheep in the country in 1923. The last animal census in December, 1920, indicated a total of 985,000 sheep. Since that time a decrease amounting to approximately 40,000 is reported, principally in the Provinces of Bohemia and Moravia. The breaking up of the big landed estates has, it is said, made impossible the maintenance of the former large flocks. As a normal shearing yields approximately 2 kilos., or 4.4 pounds, per sheep, the estimated 945,000 sheep in 1923 justify the calculation of 4,158,000 pounds for the 1923 wool crop.

The well-developed wool-manufacturing industry in Czechoslovakia requires annually, under normal conditions of full operation, about 77,000,000 pounds of washed wool. The equipment consists approximately of 450,000 spindles for combed yarns, 596,000 spindles for carded yarns, and 34,450 mechanical looms. The products vary from the coarsest yarns and fabric to the finest.

As the domestic production of wool represents only a small fraction of the normal needs of the industry, and since, as already indicated, the bulk of the domestic wool is used in home manufacture, the country is dependent almost exclusively on foreign markets for its wool supplies.

PERSIAN AMBARI HEMP PRODUCTION.

Persian ambari hemp (*Hibiscus cannabinus*), locally known as Kenaff, before the war was grown to quite an extent in Guilan and Mazanderan, Persia's two richest Caspian Provinces. Russia consumed practically the entire production. The ensuing disorganisation of the Caucasus and Russia's virtual extinction as a market wiped out this industry just as they ended Persia's formerly flourishing Caspian silk-cocoon production. Whereas in 1913-14 Persia exported to Russia 2,408,848 pounds of raw hemp and flax, valued at about £18,000—the customs returns combine the two, but hemp forms by far the larger part—its exports in 1920-21 only reached 19,760 pounds, and in the following year, 213,811 pounds. The entire exportation, both pre-war and at present, represents the raw material, shipments of hemp cord being negligible.

From a report by the United States Consul at Teheran it appears that the Guilan villager is free to plant hemp if he so desires, provided that it does not involve sacrificing the cultivation of his allotted rice fields or mulberry groves. It requires higher and drier land than rice and is commonly planted in the hedgerows. Most villagers raise just enough for their own use, Since the mulberry groves have been allowed to deteriorate, however, following the demoralisation of the silk industry, the villagers are gradually planting more hemp.

Hemp is planted in the spring and matures in the autumn. It is then buried in mud for some days and the fibre stripped off. Persian manufactures of hemp are confined to cord for domestic use. The quality of the fibre is said to be improving, but is still too soft for effective ropes of any size.

GENERAL NOTES.

Arsenic Deposits in Chile.—Several large deposits of arsenic are known to exist in Chile, principally in the Provinces of Atacama and Santiago, but apparently no serious attempt has ever been made to work them. In the opinion of the United States Consul-General at Valparaiso, the owners would undoubtedly be found ready to commence operations if convinced that the output could be sold in the world's markets at what they consider a fair price. There is a large deposit situated in the Andean foothills close to the capital and to rail transportation, and less than 100 miles from tidewater. It is understood that an analysis recently made in the laboratory of the University of Santiago shows an arsenic content of over 90 per cent.

Indian Sandalwood Oil.—The two pioneer sandalwood oil refineries working at Bangalore and Mysore City utilised 750 tons of sandalwood cut from Mysore forests during 1923, as against 508 tons in the previous year. Oil sold during this period amounted to 149,630 pounds, as compared with 115,028 pounds in 1922. According to a report by the United States Acting Trade Commissioner at Calcutta, both factories have made such good progress in the manufacture of a special grade of sandal wood oil suitable for the Japanese trade that this oil has now displaced the German product from that market. The prosperity of the industry is due to the efforts of the Mysore Government to exploit the vast forest resources of sandalwood found in the State and to manufacture a high-grade oil suitable for export markets.

Manufacture of Fish Flour in France.—The fish-flour industry, which originated in La Rochelle and is confined entirely to that centre, is of comparatively recent origin. Hitherto, writes the United States Consul at La Rochelle, the non-edible fish that were found in the nets of trawlers were thrown into the sea, but now they are brought to port to furnish material for the fish-flour plant. The one plant now producing fish-flour can handle with its present installation from 8 to 10 metric tons of fish and fish waste per day, which represents an annual production of 450 to about 600 metric tons of fish flour. The product is used in all the agricultural sections of France and is exported to Switzerland, Spain, Italy and Germany. Fish flour has an important alimentary value since it is rich in protein and in phosphates. It is mixed with feed for poultry, rabbits, dogs, sheep, cattle, and hogs. Experiments in feeding fish flour to cows and chickens have demonstrated its value in increasing the production of milk and eggs.

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FRIDAY, AUGUST 8, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2).

NOTICES.

INDIAN SECTION.

A meeting of the Indian Section Committee was held on Wednesday, July 30th. Present: Sir Edward A. Gait, K.C.S.I., C.I.E., Ph.D. (Chairman of the Committee) in the chair, Sir Charles H. Armstrong, Sir George C. Buchanan, K.C.I.E., Sir Krishna G. Gupta, K.C.S.I., Sir Claude H. Hill, K.C.S.I., C.I.E., Major-General Beresford Lovett, C.B., C.S.I., Sir John O. Miller, K.C.S.I., Mr. N. C. Sen, O.B.E., Major H. Blake Taylor, C.B.E., and Mr. N. N. Wadia, C.I.E., with Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

COMPETITION OF INDUSTRIAL DESIGNS.

The Exhibition of selected works submitted at the Society's Annual Competition of Industrial Designs is now being held, by the courtesy of the Director, in the North Court of the Victoria and Albert Museum, South Kensington, S.W., and will remain open until Saturday, August 30th. The designs exhibited are divided into the following classes: Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. The Exhibition is open to the public free daily from 10 a.m. to 5 p.m., and on Thursdays and Saturdays from 10 a.m. to 9 p.m.

PROCEEDINGS OF THE SOCIETY.

TWENTY-THIRD ORDINARY MEETING.

WEDNESDAY, MAY 28TH, 1924.

LORD ASKWITH, K.C.B., K.C., D.C.L., Chairman of the Council, in the chair.

THE CHAIRMAN said those present were going to hear a paper entitled "The position of the Arabs in Art and Literature," a great subject, of very wide extent and very difficult to compress within a short compass. The lecturer was a lady whose name had become well known throughout this country, and, he might say, throughout a great many other parts of the world. She was an enterprising traveller, who had been to places very few European travellers had ever visited, and possibly to some where no European traveller had been. She had written books about her travels and adventures, but, more than that, she had studied the history and the art of the peoples among whom she had been. That history and that art varied in different countries where the Arab conquerors had spread themselves, and where they had either adapted the traditions of the country to which they went, or had impressed their views upon it.

He did not wish to anticipate one word of what the lecturer was going to say, but he would introduce her at once, particularly as the Spanish Ambassador, who had favoured the Society with his presence that afternoon, and whose country was highly interested in matters connected with the Arabian movement, had to leave early and would desire to hear as much as he could of the lecture.

The paper read was:—

THE POSITION OF THE ARABS IN ART AND LITERATURE.

By MRS. ARTHUR MCGRATH (Rosita Forbes).

The position of the Arabs in art and literature is an immense subject to be tackled in one paper, especially as such position can only be defined by reviewing what the rise and decline of the Arab races have left us. Arab art alone covers architecture, wood carving, ceramics, miniatures, ivories, carpets, stuffs, arms, bronzes, incrusted metals, gold and silver work, enamelled glass and illuminated MSS., while their literature is one of the richest in the world.

Herodotus, Eratosthenes, Artemidorus, described the marvels of Arab art which existed centuries before Christ at Mareb, the city of the great dam, and it would appear that in the Sabæan and Himyaritic kingdoms the pervading influence was first Indian and then Persian. From pre-Islamic days the gold work of Yemen has been famous throughout Arabia, and, though it is continued to this day, the oldest designs

are still the best. The rock city of Petra and other early ruins show traces of Arab art, but much must have been destroyed by the primitive Moslem conquerors, who regarded the representation of figures as idolatrous. With the rise of the Caliphate, art was patronised by the ruling princes, and there was an influx of artists from Persia, Egypt and Syria.

There were no books on art, though ornamental designs were found in works on geometry and architectural drawings in miniatures. Designs were handed down in families and kept secret. Some of the earliest of these were used in carpets and embroideries, and the sculptors of the West reproduced them, as in the mouldings of the doors at Konia and at the Sebil of Kait Bey, near the Al Azhar University. In Cairo there are columns carrying out carpet designs, and in the Tunis museum is preserved woodwork which is a copy of embroidery. The art of the goldsmiths gave the ideas for the mosaics at El Aksa in Jerusalem and Qubbet es Sakhra. Early tiles were copied from Persian stuffs. The first descriptions of art concern the products of weavers and jewellers. Abul Feda, writing of the reception of an ambassador by the Caliph of Bagdad, describes a hall hung with 38,000 pieces of tapestry, of which 12,500 were embroidered with silk; and a golden tree with swaying branches, from which sang all sorts of jewelled birds. The Arabs conquered countries that were always more advanced artistically than they were themselves, so they were of necessity influenced by the taste of the subjugated nations. In Iraq early Arab art was influenced by Sassanian, Chaldean and Persian; in Syria, by Copt, Byzantine and Egyptian; in North Africa, by the neo-Latin art of Spain, Byzantine and a little Greek and Roman. The minarets of Samarra in Iraq show Chaldean influence and the towers of Ibn Tulun, Cairo, are similar to those of Babel, and the Chaldean Ziggurat, observatories. The Chaldean and Assyrian method of baked clay decorations and of beaten sheets of metal exist to-day in Iraq, as in the mosque of Kazimein, near Bagdad, with its tiles of gilt copper.

Parthians, Romans, Persians, Byzantines fought for Syria, which was the bridge between Asia and Africa, and even Yemen was subject first to the Sassanians and then to the Persians up to the time of the Prophet. The so-called Arab arch found at Sidi Okba, Kairawan, Cordova, Jerusalem is seen in the Sassanian monuments of Takht-i-Ghera. Professor Pelliot showed a picture in a recent lecture of the same arch in a Buddhist cave in Chinese Turkestan of a much earlier date. The plaster mouldings which are typical of Arab architecture were originally Sassanian.

After Yemen, it was Iraq which first established itself as a centre of art, and, from Iraq have come, but often by way of other civilisations, the so-called Arab arch, the vaulted roofs, enamelled earthen walls, the metal plates for domes and the decorative mouldings. In the first centuries of the Hegira the Arabs took their decoration, not their architecture, from Byzantium, and it was the artists of Jerusalem, Cordova and Damascus who came from Constantinople. After the Turkish conquest the great Byzantine monuments influenced Arab architecture, while the decoration became Syro-Egyptian. The octagonal Qubbet es Sakhra was one of the earliest Syrian edifices purely Byzantine, but, from Constantinople too, came the carved wooden doors, marble faced walls, bronze laid on wood, carved marble screens and windows, mosaics in all forms. The Khans, of which there exist some exquisite specimens in Damascus, were a Byzantine product, and Byzantium inspired the great military architecture of Palestine during the Crusades, and her cisterns, learned from Rome, are copied all over North Africa. The Byzantine dome replaced the early Sassanian or Mesopotamian, and mosaics the ceramics, as in the mosque of Omar at Jerusalem. The Arabs became very expert in this latter branch of art, and they established it in Spain, where the Cordova mosque is decorated with mosaics of glass. It must be confessed, however, that though possibly the Arabs developed this Art, the Roman ruins in Algeria and Tunisia show the same marble and cut porcelain mosaics (the opus sectile of Rome) as in Cairo, Damacsus and Tlemcen.

Typical of Arab art is the use of geometrical designs, but in Italy, in Roman mosaics, in Baalbek and in Palymra, there are traces of the same designs, and they are found in Sassanian stuffs. It would seem, therefore, that the Arabs perfected a certain style of Eastern architecture and decoration without originating any portion of it.

The early mosques of the Iraq or first Arab school had a square court with a

fountain in the middle, surrounded by porticos, the deepest being on the East and holding the mihrab. They owed their beauty to paint and gold leaf, not to their rich materials, as may be seen in Ibn Tulun in Cairo. As the Syrian school replaced that of Iraq, the mosques show precious marbles, metals and enamels. Nur-ed Din built several of this kind in Damascus. In the 13th century there appeared, originally presumably from Iraq, where the four Islamic Codes had birth, later from Syria, the cruciform plan on which so many Cairo medersas are built (typical of the four orthodox rites, Hanbali, Shafei, Maliki, Hanafi).

Under the Fatimite Caliphs a distinct Syrian style developed, and the architects who constructed the three great gates of the Cairo fortifications were Syrian. The Fatimites were Shias and heterodox, so in the decorations of their period one finds human figures and animals, but they disappear again under the Ayyubites. The use of stone, of many coloured marbles, of stalactites, and of scientific instruments came from Syria, and her architects are responsible for some of the finest Arab buildings, while their influence in details persisted even after the Turkish conquest. The Syrian architecture differs from the Byzantine in its abundance of floral decorations, but in Egypt and North Africa ancient columns, brought from Roman and other ruins, are often used in early Syrian mosques. It is rare to find in Egypt columns made by Moslems. Even the architecture of Constantinople is borrowed from the Syro-Egyptian school. Many of its monuments have disappeared, the earliest in the Crusades or the wars of the Mongols and Turks, when Aleppo and Damascus were sacked. Later buildings were destroyed when the Mameluke Sultans tried to re-establish their authority in Syria. Such wars, however, were responsible for the perfection of Syrian fortifications.

Typical of this school are the Moslem charitable foundations, often connected with the tomb of the founder, as at the Moristan of Kalaun in Cairo, where, within one wall, are the tomb, a mosque and a hospital. Other buildings associate with the tomb, fountains, schools and mosques. To the Syrian school are due some particularly fine public baths, and the caravanseries, which were at the same time mosques, schools, hospitals and fountains.

The Turks introduced the many cupolaed mosque, but made no impression on civil architecture. I have seen their mushroom cupolas in the big mosques of Yemen and even in the desert mosque at Aujela on the way to Kufara. Under the Mameluke Sultans the palaces and civil buildings in Syria and Egypt grew richer in decoration, and it is to this period that some of the most exquisite interiors in Damascus and Cairo belong.

During the first centuries after the Hegira Kairawan, the capital of the Aglabites, and Cordova of the Omeiyads were the centres of Western Art. In the 9th and 10th centuries A.D. Morocco was the cradle of a new brilliance, not uninfluenced by the Berbers.

Fez, with its exquisite mosques and colleges, was founded in 807, and Marakesh two hundred years later, but when Spain was conquered by the Sultan of Morocco in the eleventh century she was not impressed by this Moorish art. On the contrary Spanish Arab art, then producing its best, created some remarkable monuments in Morocco. In the 12th and 13th centuries this renaissance of the West spread into Algeria and Tunisia, and reached its climax in the 14th and 15th.

Curiously enough it was not till after the fall of Granada in 1494 that Western Arab architecture took its most definite form. The ancient style can be seen in the fortifications of Granada, Cordova, Seville and Toledo, in their palaces and their mosques. The later typical Western mosque had parallel naves and a wider central nave, with the mihrab as a tower, a square minaret and a great porch richly decorated, and this served as a model for many North African mosques, which were generally built over cisterns, to which water flowed from terraces. The West has no cruciform medersas, as the Malekite rite is supreme. Its medersas are simpler and contain rooms for students. Its zawias are like large Arab houses, sometimes adjoining the tomb of the founder, as at Jarabub in Lybia. The fortified zawias (such as Sousse) were colleges and fortresses belonging to the religious military orders, which, under the Almoravide Sultans, had so much power. The fortifications of the West are among the most interesting in the Arab world, especially those of Sfax, Sousse, Fez, Meknes, Tlemcen—with their massive square towers and double

walls, sometimes crenelated, the towers alternating on the two walls.

After the 16th century Western Arab art declined under European influence. Many Algerian mosques were built after the plan of churches, and both the architecture and the faïence were copies of the Spanish and Italian.

General Lyautey in Morocco has done much to encourage the revival of Arab architecture; and Raisuli's great palace at Azeila is an excellent example of modern Arab work, but the Mediterranean countries have much to forget in the way of European tawdriness before they can go back to their old art. In Xauen, a little time-forgotten town in Spanish Morocco, there are some beautiful, fairly modern houses built after the old style with the two tiered galleries supported on double arcades, round a central court, but the most interesting modern purely Arab domestic architecture I have seen is in North Yemen and Asir, where the late Emir Mohamed el Idrisi, himself no mean architect, encouraged the merchants to build large well-proportioned houses after his own model at Sabya; and in Jedda, where mason and wood-carver go out together to the selected site and plan the rooms on the spot, the wood-carver receiving 20 per cent. more than the mason because his work is more precarious. From Mr. St. John Philby's careful descriptions, the great palace of Ibn Sa'ud, at Riadh, must be a fine example of modern desert architecture, but this has changed little with the centuries, since its style is regulated by the quality of material and labour obtainable on the spot. Unfortunately, the secret of the peculiar glaze used on the decorative Arab tiles has disappeared. Sayyid Dahan has been experimenting on this for some time in Damascus, and has actually succeeded in reproducing the old bluish green colour in a form of paint. This has been tried on the roof of one of the new public buildings, and, so far, it appears to be identical in effect with the ancient material, which had the quality of always looking fresh.

Arab painting was hampered not only by the stern inhibitions of primitive Islam, but by the recurrent puritanical movements, the last of which is the Wahabi, which were always opposed to any form of art or luxury.

Makrizi mentions mural paintings in the palace of Ibn Tulun, and the Fatimite Caliph, Mostanser Billah and his Vizier, Yazuri, were much interested in illuminated Korans. Ibn el Aziz, of Bussora, painted the former's walls, using red figures against a yellow background; but nothing remains of the work Makrizi describes, nor of that Abu Bekr Mohammed (d. 975) mentioned by Abul Feda. Monsieur Musil, the Czecho-Slovak Arabist, who spent twenty years among the Shammar Arabs, discovered mural paintings at Kosseir Amra in the desert East of Moab, which are supposed to date from the 9th century. In the Alhambra are paintings on leather of hunting scenes and councils, which, by some (notably Gerault de Pranzey) are supposed to be Arab, by others Italian.

Moslem art excelled in illuminated volumes—the name of the painter is often dissimulated in minute characters in the corner of a scroll—but the best were Persian, for the Shias were not hampered by the scruples of the orthodox concerning human and animal figures. There is a great sense of movement in some of the hunting scenes, and a French authority points out that "Certain drawings by their precision of feature and subtlety of line are not unequal to the drawings of Ingres; certain animals not unworthy of Pisanello." Few illuminated missals can be attributed to the devout Arabs of the early centuries of the Hegira, but after the 13th century they made progress in the art. Under the Ayyubite dynasty the first illuminated MSS. lacked imagination. They showed Byzantine influence and saintly halos sometimes crept in by mistake. The most important existing Arab MS. is a copy of the Muqamat of Hariri containing 101 miniatures, executed in Iraq in 1237, and of great value, since it represents historical scenes in the correct clothing.

The Arabs eventually excelled at illuminating Korans, geography and natural history books. An example of the latter is the curious "Marvels of Nature," dated 1283, in which the drawings are fantastic and unreal, but full of imagination. The most exquisite art was expended on a thirteenth century Koran in the British Museum, of which certain pages give the impression of rich silk carpets, but the finest Korans are in the Arab Museum in Cairo.

The same museum shows admirable specimens of wood-carving of the 15th to 17th centuries. In those years the highest art was expended on the mim-

bars and mihrabs, lattice work for windows, doors and friezes. Syria was rich in hard wood, such as pines and cedars, and probably exported to Egypt. Early examples of the carver's art were found in the tomb of Ain el Sera of the 8th or 9th century. The mosque of Ibn Tulun, in Cairo, has the whole Koran carved into a decorative frieze. The panelling of houses and medersas was particularly fine, though it had to be done in small panels to avoid shrinkage from the sun, and boxes to hold the Koran show a wealth of beautiful detail, getting richer as the years advanced. In the 14th century ivory was used to decorate doors and panels, and these two arts have suffered perhaps less than any others in the decay of Arab power. The woodwork of Syria and the Hedjaz and the decorative designs in ivory, which are so finely done that it looks as if the wood had been embroidered with ivory thread, are still admirable.

There is in the South Kensington Museum a cup of carved ivory made by Mohammed Saleh in Cairo, in 1521, with the inscription "In truth the righteous shall drink from a cup perfumed with camphor," which marks the apex of the Arab ivory work. This art was famous in Spain in the 10th and 11th centuries, and the coffers, goblets, handles, plaques, often decorated with animals and human figures in high relief, show an imagination fertile, ingenious and complex.

In the Bargello, in Florence, there are two ivory plaques from the 14th century Iraq, carved, one with winged griffons, and the other with human figures, among vines. These are among the finest known specimens. The Arabs also worked in cloisonné, enamels, engraved copper, silver and encrusted metal. Exquisite specimens of these arts are preserved in the European and Arab Museums, and the various schools of native art and industry in Spanish and French Morocco, Tunis, Syria, etc., are endeavouring with some skill to reproduce the old designs. Damascus has succeeded to a certain extent with her metal work, and there seems to be a distinct future for this branch of Arab art.

It is a pity that the making of arms has so completely died out. Yemen is still famous for her hilts and scabbards, but she imports the blades. Modern Moorish blades are but a poor copy of the old Spanish Arab work. In the 13th century Cairo was the great market of arms, but in those days it was the quality of the blade which appealed to the Arab; the ornamentation of the hilt was less important. An existing Arab proverb says: "There is only one gift for the brave--a blade." Syrian blades passed on from one generation to another with the addition of different hilts. In the list of gifts sent by Sultan Beibars to the Ilkhan of Persia, Abaga, were arms from Damascus. The sword of Duke Emanuel Philibert of Turin, in the 16th century, had a Damascan blade, but 100 years previously, the Syrian workmanship had passed its zenith, though "Damascan" remained a generic term for finely tempered steel. The Arabs brought the perfected industry to Spain, though it had already existed to a certain extent at Toledo, and it was in Spain that the ornamentation of arms attained its greatest richness about the 16th century. The sword of Boabdil II., last King of Granada, is preserved at Madrid. The blade is from Toledo, the gold hilt enamelled in blue, red and white, with a centre of carved ivory, and it bears a Kufic inscription: "Attain your end (but) in safeguarding your life."

Stuffs of all kinds have formed an important part of Arab art.

Coptic influence shows in the early Egyptian Arabic tissues, but the introduction of animals and figures was due to Persia. Geometrical designs were often interwoven, together with verses of the Koran, or lines in praise of the future owner of the stuff. It is sometimes possible to tell the date by such inscriptions. In 774 Egypt provided the hangings for the Ka-aba at Mecca, and these grew in spendour till Ibn Jubair, visiting Mecca in 1182, describes and admires the richness of the 34 strips of green which covered the whole of the outside, and were themselves covered with woven inscriptions. Makrizi describes a tapestry made for a Fatimite sultan, which represented the earth, with all its known cities, seas, and mountains, rivers and roads, the names woven in gold and silver.

During the middle ages Alexandria was world-famous for her tissues and European merchants came there to buy them. As early as the 8th century chroniclers speak of caravans returning from fairs at Damascus and Aleppo laden with precious stuffs, embroideries, tents, cushions, mattresses and purple silks.

In histories of the Crusades constant mention is made of Damascan brocades.

Marco Polo says that even the beds in the post-houses had curtains of silk, and at Mosul he notes the silk brocaded with gold called "mosulin," the origin of muslin. During the Abbassid Caliphate at Bagdad, portraits of famous people were woven in silks, and in the 14th and 16th centuries the school of Mosul was famous for its tapestried hunting scenes, with lion, hare, gazelle.

Zobeida, wife of Harun al Rashid, is supposed to have founded Kashan, famous for its velvets, brocades, carpets woven with gold, taffetas and cut velvets. These Kashan carpets, since gold was used in them, were probably not the knotted carpets at all. These seem to have originated in Persia, but, under the Ayyubites, fine carpets were made at Emessa in Northern Syria. A 13th century carpet with Arab inscriptions is supposed to have come from the Mohed Din mosque in Damascus. Early carpets are best studied in the old Flemish and Italian pictures, and it is probable that some of the carpets thus portrayed came from Syria and Asia Minor, and were brought from the Mediterranean coast by Venetian mariners. Still, carpet making can never have been a definite Arab art, and I am afraid the recent efforts by hand and loom seem to prove that it never will be. On the other hand, the modern silks interwoven with metal thread of Syria and Morocco are very beautiful, as are some of the embroideries.

It may be interesting to consider the influence of Arab art on the Europe of the Middle Ages.

Omeiyad coins have been found in Poland, Russia, Denmark and Sweden, and in the Carlovingian period Arab sailors went out into the Atlantic. With so great a commerce there must have been an entry for that Eastern art, described by an authority as being "second to none in richness of decoration, harmony, brilliance of colour, and fantasy governed by rigourous logic." Rome took her "tree of life" and her two-headed animals from the Arab, though the griffon was originally Sassanian. Certain Arab designs are found in French and Spanish architecture, and, in the Renaissance, copper, silks and ceramics all showed Moslem influence. In Southern Italy there are traces of the same in architecture, and in bronze, silver and woodwork.

It is strange that so rich and varied an art, even if it was adapted rather than original, can have died out to so great an extent. It may be due to constant wars resulting in alien domination, to European influence, to recurring waves of puritanism, or perhaps just to the fact that, though perfected by the Arabs, it was not born in them and part of their being, as is their literature. In their present struggle for political existence, their art has no part, but their literature is, at once, an inspiration and a weapon.

The least emotion turns the townsman into an orator, the Bedouin into a poet. From earliest times the desert men have sung to encourage their camels on the long night marches, the merchants have confounded each other in the market place with their caustic rhetoric. Words often rank higher than deeds in the Arab mind, and, whereas I have never heard a warrior praised for his courage or his horsemanship, the cry "Ya Sha-ir, oh Poet!" (literally, "the man of knowledge") is the greatest honour that can be paid to a Bedouin. In ancient times each tribe had its poet, who was regarded with awe, since he was, to a certain extent, the servant of the jinns (spirits) who inspired his verse. It was his duty to hurl his satires (hija) in rhymed prose at the tribal enemy, a mixture of incantation, mockery and threat; which doubtless gave rise to the proverb, "For the wound of the tongue there is no medicine." The rhymed prose (saj) must have originated by the padding of the caravan across the desert, just as the earliest form of poem, the Qasida, reflected the nomad life of the wilderness, beginning with a description of the camp, the trials or triumphs of the journey, and ending with the praise of the tribal chief.

The first actual metre (rajaz) was a chaunt alternating two long syllables, a short and a long, and this was followed by 15 others, whose rules, however, were not confirmed till Khalil ibn Ahmad wrote in the 8th century.

The works of the most famous pre-Islamic poets, Imru ul Qais, Tarafa, Zuhair, Labid, Antara, Al-Harith and Nabigha, were collected at a later date in the seven Mu'allaqat, "the suspended." The first of these creators of the Qasida, Imru ul Qais of Kinda was a king's son, exiled for a love affair, who wandered to the Court of the Emperor Justinian in Constantinople, and was, by him, appointed Phylarch of Palestine, but was killed by a poisoned robe

on his way to his new post. The Bedouin poet Antara is famous because his adventures formed the basis of the romantic epics of the middle Ages, which, in many hundred verses, deal with his legendary loves and battles. Antara was of negro blood, slave-born, yet his courage in battle made him the hero of the tribe of Abs and the adopted son of its chief. He sang of the battle of Al Faruq, "We whirled as the millstone whirls upon its axis, while our swords smashed upon the fighters' skulls," and of Abla, the Chief's daughter, "whose smile was like the sunshine flashing on swords drawn in battle."

Zuhair is generally cited by Arabs as the greatest of the seven, though some choose Imru ul Qais or Nabigha. Zuhair was a moralist, who cared nothing for flattery, "which does not ensure immortality," and his poems are serious and peculiarly honest in that they make no use of borrowed phrases, and avoid all complicated and incomprehensive simile. He came of a family of poets, for el Khansa, who wrote elegies on the deaths of her two brothers in war, was his sister, and his son Ka'b was condemned to death by Mohammed for the idolatry of his poems, and only saved himself by a panegyric which the Prophet's vanity could not resist. His father Aus Ibn Hajar wrote famous descriptions of weapons.

The Grammarian Al Asmai made another collection of the works of six of these poets at the beginning of the 9th century, but included Alqama, who wrote the famous comparison of his camel and a desert ostrich, and omitted Labid and Al Harith.

The subsequent Diwans (collections of poems) show us the gradual evolution of Arab poetry, but until the days of the Omeiyad Caliphate, the desert spirit prevailed. We have descriptions of oases, of camel skeletons, with the flesh hanging on to the bones "gleaming like the teeth of a slave girl," of single combats between tribal heroes, of tent life and, after the 4th century, of horses.

The tribe of Abs produced another hero poet, whose generosity was only rivalled by that of Hatim Tai—"I would cut up my body to feed my guests," he said. Dhul Asba al Adwani expressed an ideal for all warriors—"Use thy goods nobly; make thyself the brother of all generous men. However wide the distance never forget the debt thou owest to thy brother and the poor. Rush into battle where the most intrepid shuns the charge, and, when thou art summoned on an important matter, take all the burden of it on thee."

Of Hatim Tai's prodigious generosity there are as many fables as of the courage of Antar. As a boy he is said to have presented his grandfather's herd of camels to some passing poets, and, when he was disowned by his people for the deed, he sang: "I suffered not when Sa'd and his family departed, leaving me lonely in my home, parted from all my kin. By squandering my fortune, I have won swift glory." To-day, if Bedouins are hungry in the desert, they pray to Hatim Tai in the rhymed prose of 1,500 years ago, to provide a feast for their need.

The earliest Arab prose was unwritten, like the poetry. Story-tellers used to go from camp to camp telling the "samar," long repetitive descriptions of battle and heroic adventures.

At fairs and markets orators were urged into trials of eloquence, of which the audience were the judges. It is probable that Mohammed listened to the rival poets at the famous yearly fair of Ukaz, where a wreath was given to the victor and the winning poem pinned upon a tree. The story-teller had a choice of relating the history of some great living chief, usually the hero of his own tribe, or the fabulous adventures of a more or less mythical personage. A famous story-teller, Nadr ibn Harith of Mecca, used his knowledge of ancient Persian legend to rival the eloquence of the Prophet in the biblical stories which he used in the Koran.

Mohammed was perhaps influenced by the poets of his era, since some of their expressions (such as Umayya ibn Abu Salt's description of the day of judgment as the "day of mutual disappointment,") have passed into the Koran, but he condemned their works as idolatrous, and ordered various contemporary poets to be executed.

The Koran, which Mohammed tells us was inspired by the Archangel Jabril, (Gabriel), is the finest monument of rhymed prose, but the style varies between the early suras which consist of short verses, and the long chapters revealed at Medina, where the rhythm is only marked in the pause at the end of each verse. The present arrangement is, of course, artificial, for none of the Suras were written down during the

Prophet's lifetime. Four of his disciples are supposed to have memorised the whole revelations, and, under Omar the fourth Caliph, Zaid, who had been Mohammed's secretary, superintended the writing of the first Koran. As, however, no text was accepted unless two witnesses for its authenticity could be produced, much that was genuine was probably omitted.

The rise of the Prophet produced a new movement in Arab literature. It was first seen among the contemporary poets, who employed all their art in singing the praises of the warrior Prophet. Labid was one of the first impressed by the recitations of the Koran at Medina. He sang his conversation from paganism in similes of power and beauty, but, once a Moslem, he looked upon his poetry as heathen and refused even to talk about it.

Hasan Ibn Thabit deserves mention as the poet laureate, the "Mirror of the Prophet," but he has none of the colour of his pagan predecessors.

Only religious poetry was encouraged under the early Caliphs, but a formidable development of literature occurred in the collection and arrangement of the sayings and traditions of the Prophet.

Under the Omeiyad Caliphs, the influence of town life began to be felt in Arab poetry. The nomads still sung their improvised rhymes to the beat of their camel's hoofs, as they do to-day, but the centre of literature was the court at Damascus, and the object of the poet to acquire the patronage of prince or courtier. Poetry became artificial in its exaggerated panegyric of the ruler, or satire of the rival. Al Akhtal, who was a Christian, Ferazdaq and Jarir, were the most famous poets of the Omeiyads, and the epigrams they directed at each other were the delight of courtiers, who never dared to pronounce in favour of one for fear of encouraging the stinging satire of the others. Later generations preferred Al Akhtal on account of his finished style and his apposite expressions. His moral sentiments were possibly due to his desire for the favour of Caliph Abdal Malik, of whose house he wrote: "Terrible in their rage if they are withstood, they are the most clement of men when victory is won!"

Ferazdaq was a cynic who used his great command of language in ribald verse, often directed against women. He seems to have been a vicious libertine, a coward and a plagiarist, yet his satire was so feared that no one would bear witness against him.

Jarir was a man of Yemen, who lived in Iraq and sought the favour of Caliph Abdal Malik, denied to him on account of Akhtal's jealousy. He was a mighty fighter with his tongue, and is supposed to have crushed 43 rivals at the popular tournaments of oratory. Both Jarir and Farazdaq, rivals to the end, died in 728.

A woman poet, Leila el Akhyariya, who died in 706, is famous like her predecessor, el Khansa, the "vivandière" of Mohammed's battles, for her elegies, especially for that dedicated to her lover, Tauba ibn al Humayir. She was welcomed at the courts of Abdul Melek and the Governor of Iraq, and was perhaps the best known of the women orators, poets and preachers, who flourished in the early days of Islam. Another Leila is famous in the 7th century, because of the verse written in her honour by Qais ibn Mulawwah, of the tribe of Beni Amer, known as the madman of Leila. Probably this is the most popular love poem in the Arab language, and it is constantly, if unconsciously, added to by the admirers who quote it to-day. I pointed out to one Yusuf of the Emir of Asir's household that I had never heard the verse which he was obviously improvising concerning Qais' beloved. "Oh", said he, "the man was mad, so he could not remember all about Leila!" and went on with his imitative metre.

Towards the end of the Omeiyad dynasty the contact of Moslems and Christians at Damascus gave rise to much theological literature, none of which has been preserved, but we know that Hasan Basri (d. 728) whose pupil Wasil ibn Ata founded the Mutazelite school of rationalism, was the great doctrinal leader of those days.

When the Abbassid dynasty ousted the Omeiyads and established the Caliphate at Bagdad, Arab literature began to be affected by the creative and original genius of Persia. It is curious that, while Arabic was so much the diplomatic tongue of those days that Persian scholars wrote in it, the Iraq poets, philosophers, and theologists, who made the succeeding centuries the golden age of Arab literature, were dominated by the Arian imagination of the neighbouring race. Under the new Caliphs, the greatest posts were held by Persians, and at one time the Barmekid viziers were as powerful as their Arab rulers. Tribal feuds and

glories were no longer the basis of verse. The Qasida was doomed and Bedouin poetry swept back into the desert, where it remains unchanged to this day. Life became the subject of poetry, cynical, passionate and heretical. Muti ibn Ayas, of Palestine, who was protected by Ja' far, son of Caliph Mansur, wrote with depth of feeling and made the most of wide descriptive powers, but his poems are often coarse. Bashshar ibn Burd (693-783), though claimed by the Arabs, was really a Persian by blood, and he extolled his own country at the expense of Arabia. He was blind and apparently a Zoroastrian in secret, since he wrote: "The earth is dark and Fire is brilliant. Ever since it has existed men have worshipped it."

With the Persian influence came a revival of the wine songs which had existed since in pre-Islamic days, the Christian Ibads were masters of the wine trade of the Euphrates, and sung the praises of their wares as they travelled from Arab town to camp.

Abu Nuwas was the leader of the Bacchic poets of the 8th century. He went to the desert to learn the pure Bedouin tongue, and returned to the splendour of Caliph Harun's court to sing with breadth and force, not only of the grape, but of the joys of hunting, together with love lyrics and the usual panegyrics and satires. Under Caliph Mutawakkil we hear of a woman court poet called Fadl, who was also a story-teller to the harem. Her lover Said told her "Thou art like the sun that lights the world; its rays seem close to us, but who can reach it." Another woman, Mahbuba (the well-loved), composed stanzas, which she sang to her own accompaniment on a lute.

With the development of music and dancing under Mutawakkil, there were many singers who composed both verse and music, but an element of buffoonery is noticeable in the play of retort. Ibn Al Rumi, poisoned by order of the Vizier, was asked by the minister where he was going. "Where you have sent me," retorted the poet. "Give my duty to my Father" replied the Vizier, amused at his victim's perspicacity. "I am not going to hell," answered Ibn Al Rumi, and retired to his house to die.

Abu Tammam and Al Buhturi, in the middle of the 9th century, tried to revive the old poetry, and, besides collecting the Hamasa (a collection of ancient warriors' deeds published by Freytag and translated into German), wrote descriptions of the great Aleppo plain in the style of the early Bedouin poets.

In the 10th century, under the Hamdanid rule at Aleppo, we find the apotheosis of Arab literature. While Persian and Turk struggled for the military leadership at Bagdad, Saif ad Daula defended Aleppo against Byzantian Romans and patronised the greatest and last of the real Arab poets, Mutanabbi. Born at Kufa in 905, he had been brought up by the desert Bedouin, and was regarded by some of them as a new Prophet. It was in prison that he wrote his first poems, and his imagination produced such fantastic imagery that he has been criticised for "empty chatter." Nevertheless his wealth of simile is picturesque and often apt. "It was as if the soldiers saw with their ears" he wrote, describing a march in a black cloud of dust. Forty commentaries have been written about his works, and one author, confident of the poet's superiority to all others, writes: "Rhythm is subject to his will, and thoughts are his slaves."

Unfortunately his exaggerated imagery, his affectation, the preciosity of his expressions, redeemed in his case by genius, had a bad effect on his successors, and Arab poetry began to descend to false values. Al Nami succeeded Mutanabbi as Court poet at the end of the 10th century, and he is chiefly remembered for his wit, often directed against himself, as when he addressed his solitary black hair: "I say to my white hairs, which are terrified by this stranger's presence, Respect her, I entreat you. A black African spouse will not tarry long in a house where the second wife has a white skin."

In Syria, in 973, was born Abul Ala el Ma-arri, who shares with Mutenabbi, according to contemporary criticism, the position of the last great poet of Arabia. He was a pessimist and a misogynist, yet he is admired above all others by a race which has neither of these qualities.

He became blind as a child, but his memory was amazing and gave rise to many legends. His letters are remarkable, and his poems, in spite of their bitter cynicism, worthy of admiration. It is supposed by the latter Syrian critics that the quatrains of Omar Khayam are based on Abul Ala's verses on the same subject, and, in some

cases, the sentiments and phrasing are almost identical. Abul Ala is supposed to have said of a free-thinking Koran which he compiled and which someone criticised, "Let it be read from the pulpits of the mosques for the next 400 years and you will be delighted with it." He was unmarried and childless, and on his tomb he had engraved: "This is the crime that my father committed against me, but which I have committed against nobody."

The 12th century saw the birth in Cairo of the well-known mystic poet Umar ibn Al Farid (born 1181). One of his odes is in praise of wine, but used as a method of achieving the sufi exaltation. In the rest of his works he describes the philosophic ecstasies of the sage in love with the Godhead, longing to be absorbed in to it.

Another Egyptian, Al Busiri (b. 1211) is famous for his ode to the Prophet's mantle which every Arab schoolboy learns by heart, and his ode to Mecca—the Mother of Cities—after the manner of the early panegyrists, but, with a few exceptions, the age of the great poets passed with the Abbassid Caliphate.

After the Koran, rhymed prose had fallen into disfavour except among the Bedouin, till Ibn Nubata (b. 946) revived it in his sermons at the court of Saif ed Daula. These dealt with the duty and glory of the jehad, the Holy War, and have served as the model for countless sermons preached throughout succeeding centuries.

Abu Bakr el Khwarazmi, nephew of the great historian Tabari, was one of the many scholars who practised the art of letter-writing, perfected by the blind Abul Ala. Of him a contemporary wrote: "Abu Bakr has learning and talent, but his friendship lasts from morning till darkness, but no later."

The word "Maqama" (seances) had for some time been used to describe the gatherings of scholars who vied with each other in rhymed orations, improvised verse and proverbs, but it was Hamadani (990 A.D.) who produced, under this name, the first volume of short stories, concerning the adventures of beggars and wastrels. He was followed by Qasim al Hariri (b. 1654) who wrote a brilliant course of 50 lectures on the adventures of the fictitious Abu Zaid, a personage who, on account of his originator's skill and ingenious fancy, is now as real to the average Arab as Harun al Rashid.

The verbal stories of desert life had changed under the Abbassids to borrowed tales from India and Persia. As early as 750, the Persian Abdallah ibn al Muqaffa had translated into Arabic "The Book of the Persian Kings," and this was followed 50 years later by translations into Arabic from Greek philosophy and ancient history. The "Thousand and one Nights" was originally based on a Persian book of the 9th century and stories from Bagdad and Egypt were added. The present form dates from about the 13th century. While at court and in the towns these borrowed tales of love and sorcery, of fantastic verses and legendary battles were very popular, the desert was producing a type of natural history fable not unlike those of La Fontaine. These were unwritten, but they have been handed down from generation to generation and are told to-day in Arabia, probably with little difference in form. Of such are the dispute between the camel and the sand grouse as to which is the cleverer, and the rivalry between the stallion and the gazelle.

The Science of the Hadith, or sayings of the Prophet, has created such a volume of Arab literature that it is impossible to treat it at any length. The earliest sincere attempt to collect the traditions in chronological order was made by Bukhari (b. 810), under the title of Sahih (the Correct) which includes 7,275 traditions out of the 600,000 from which he had to choose. Another "Sahih" is from the pen of a contemporary Abul Hussain el Muslim, and these two are accepted among the six canonical works of Islam. The other four are the Sunan (customs) by Abu Da'ud; the Jami (complete collection) of Abu Isa al Tirmidhi; the Sunan of Abdul Rahman al Nasai and the Sunan of Ibn Maja, all of them more or less contemporary. Shortly after the Science of the Hadith, arose that of the criticism of the authorities and authors of the Hadith, which produced innumerable works. Side by side with this science of tradition and criticism, jurisprudence was establishing itself, and, in the early part of the 8th century, we have the first of the four great Islamic schools of law, the Hanafite, due to Abu Hanifa ibn Thabit from Kufa. This was followed by the Malekite, Shafi'ite and Hanbalite schools, all of them established within a century, by Abu Abdallah Malik ibn Anas (b. 715), Mohamed ibn Idris al Shafi (b. 767) and Ahmad ibn Mohammed ibn Hanbal (b. 780),

respectively. All of these masters wrote books on their interpretation and use of the sayings and the traditions, which were followed by the numberless works of their pupils. These are the existing four codes of Islam to which all Sunni or orthodox Moslems belong and which are studied in the Arab universities and zawias.

Jurisprudence is, after the Koran, the favourite study of the Arab, and the basis of an Alim's education.

Probably after jurisprudence, the bulk of Arab literature is concerned with history. The earliest pre-Islamic histories are concerned with the Yemen, but they were unwritten. They were a collection of eye-witnesses reports passed on from one generation to another. The historian who eventually collects them does not criticise, but, if he gives several different stories of the same event, he states which he believes to be the best. We hear of Caliph Moawiya sending for a Yemen scholar, Abid ibn Sharya, to relate to him the history of his country, but the earliest written histories were probably the "Maghazi" dealing with the wars of Mohammed. Many Arab scholars wrote history for their own benefit and had their works destroyed at their deaths. Thus Hassam of Basra, who died in 728, wrote the sayings of the Prophet, but ordered his son to burn them. Students of Arab poetry were obliged to know the history of the heroes whose deeds and whose battles the poets sung, and the tribal genealogies often go back to Noah. Under Omar's Caliphate, genealogies were collected in towns, because of the pensions due to descendants of the Prophet. The earliest written histories are confusing, because sometimes the writers speak as if they had witnessed the event themselves, and, later, in quoting from books, they suggest that the authors had informed them verbally. Sometimes the historians make one consecutive story, but quote an authority for each portion.

Historical romances existed since very early days, and a new note was given to them by the adventures of the Prophet and his son-in-law, Ali. The story of the tragic death of Husein, attributed originally to Abu Mikhnaf has been the basis for a thousand tales, just as the life of Antara served as a model for later epics.

There were fabulous romances of the conquest of Spain by Ibn Habib, and of the fall of Egypt by Ibn Abd el Hakam, and some of these were accepted as truth by the later historians, with the result that their works are full of inaccuracies.

The romantic stories of Saif Dhul Yazan, a prince of Yemen, who was suckled by a gazelle, and of the Beni Hilal with their hero Abu Zaid, born black because his mother saw a raven defeating a flock of other birds, and prayed that her son might have its courage even if he must also have its colour, are among the best known of the romances which have grown so far from their historical origin as to leave it unrecognisable.

Ibn Ishaq, who died in 767, was the first great biographer of the Prophet, but into his work he put many fables concerning Mohammed's ancestry. "The Book of Campaigns of the Prophet," by Al Waqidi (d. 822) who is said to have had 600 chests full of books, and the Book of Classics by his pupil Ibn Sa'd are important contributions to Arab history. Al Madaini (b. 752) wrote 111 books on the history of the Caliphs and also various works on prominent women, but the famous critical historian of the period is Tabari (b. 838) who wrote the "History of the Prophets and the Kings" the first complete Arab history, which starts from creation and is mixed up with a quantity of tradition. Saladin's library in Egypt contained 1,200 copies of this work.

Tabari was the authority for later historians till 1201, when Ibn el Janzi added to his works. Masudi, in 915, started the historical romances which are so popular in the East. He was a great traveller and learned in Jewish, Roman, Indian, Persian and Christian history. His great work, from which "Golden Meadows" is taken, was in 30 volumes.

The Fihrist, belonging to the end of the 10th century, is valuable because it is a catalogue of books which, at one time, existed in the Bagdad libraries, destroyed by the Mongols in 1258, and by Tamerlane in the 16th century. The best Eastern histories came in turn from Bagdad, Spain, Alexandria and Aleppo. Whenever any great man arose we find a crowd of biographers recording his history, as in the case of Saladin, who found biographers in Persia, Syria and Egypt. Later historians included Ibn Taimiyya (b. 1263) 43 of whose works are preserved in European libraries, and who was probably the inspiration of Abdul Wahhab in his fanatical

hatred of innovation: Abul feda Ismail ibn Ali (b. 1273) author of a Universal History which is little more than an abridgement of Tabari's, and the great philosophical historian Ibn Khaldoun (b. 1332) author of the "Book of Examples," which includes the history of the Arabs and neighbouring peoples; the history of the Berbers and the Moslem dynasties of North Africa and the history of the Sicilian Arabs. The premier historian of the 15th century was Maqrizi, a Syrian, author of histories of the Fatimite Caliphs and of the Mameluke Sultans, while the encyclopaedic works of Abdul Rahman el Suyuti (d. 1505) incarnate the Arab knowledge of his century.

Even the shortest review of Arab literature must include some mention of the philosophy which was enthusiastically welcomed in Arabia in the 9th century, after it had left Greece. Al Farabi, who died at Damascus in 950, wrote 70 volumes of notes on Aristotle's treatise on logic. "If I had lived in his days I should have been his first disciple," he said. Ibn Sina (b. 980) known as Avicenna, was philosopher and doctor combined, and his writings cover the whole field of Eastern learning — theology, dreams, demonology, logic, physics, mathematics and astronomy.

Avenpace, who died in 1138, writing on the highest aim of human life, and analysing the various spiritual forms to which mental activity can be directed, foreshadowed Averroes, born at Cordova (1126-1198) the great interpreter of Aristotle, who endeavoured to reconcile Moslem law and science. He wrote on the unity of intellect, on religion as a distinct personal and inward power, not subject to dogma and scientific law. Averroism was eventually rejected by pious Moslems, but accepted by the Jews. Petrach speaks of Averroes as a mad dog barking against the Church. The school finally settled at Padua, which became the centre of Averroist Aristotelism.

Another branch of Arab science which has left a great literature behind it is magic or demonology. The principal of the magic virtues contained in the names of God and in certain other names was much studied in the West, and, after the fall of Cordova, it is supposed that many books from the Arab library were taken by fugitives to Morocco, where they are preserved in the Ahmas Mts. at the Zawia of Teledi. If this is true, it would explain the peculiar study of the Ilm el Ism (Science of the Name) carried on by the Moroccan Ulema. Mulai Sadiq el Raisuni shewed me some interesting works on the subject when I was at Tazrut last August. The science originated from the passage in the Koran "God has great names—invoque him by these names and fly from those who misuse them." *i.e.*, those who attribute wrong names to God. Mohamed in one of the Hadith, said, "God has 99 names—100 minus one; those who know them will enter into paradise." It is supposed that, by using the "great name," the hundredth, all prayers are granted.

It is the great name, which is only known to a few initiates, which makes God the servant of the name, and it is written on the best talismans and amulets.

The science of the virtues of God's names is perhaps the most considerable part of Moslem magic. The list is written on amulets—each name has a special virtue. Strict Arabs never throw away written paper for fear it may contain a Name of God.

Bismillah, the first word of Koran, is supposed to have been written on the side of Adam, the wing of Gabriel, the tongue of Jesus, the seal of Solomon.

Mulai Sadiq assured me that by means of these names he could raise the Jinn, but that it had taken him 17 years to acquire such proficiency!

Egypt was conquered by Selim I. in 1517, and, with the spread of Turkish power throughout Arabia, came the decay of Arab literature and art. Like the Persians of old, the Turks had begun to use Arabic as a literary language, but, inversely, they influenced the taste of the conquered countries. Turkish songs and music came into the harems with Turkish wives. The official classes were Turkish, and so the records were in the hands of Ottomans.

Haji Khalifa, a Constantinopolitan Turk, who died about 1670, was the first to use European sources for his histories, and he compiled a huge encyclopaedia called "Doubts Cleared Up," which is a most valuable bibliography of Arabic, Persian and Turkish literature.

This short review may give some idea of the number of Arab works during the Middle Ages, but, as it was not uncommon for a historian to compose 100 or more volumes, the vastness of the field may be imagiued.

It needed some dynamic force to awake

the dormant Arab spirit and create a renaissance of their literature. There were signs of this rebirth in the 19th century, when a quantity of Arab newspapers sprang up in Egypt, Syria, Tunis, Algeria and Morocco, Constantinople, India and even Paris.

The pioneers came from Syria, and, of them, Khalil Effendi el Khoury of Damascus was the best known. Until a comparatively recent date Egyptian journalism was in Syrian hands, and the two most famous Arabic papers of to-day—"El Muqattam" and "El Ahram," are the property of Syrians. Both these journals play a great part in Eastern politics and they have subscribers all over the world. The "Muqattam" numbers 1,000 in America and 11 in Alaska.

Sheikh Jamal ed Din el Afghani and Sheikh Mohamed Abdu used to publish in Paris, half-a-century ago, an interesting pan-Arab paper, which championed many political and religious reforms -el Urwat ul Wuthba. Several papers appeared there under the despotism of Abdul Hamid, and, during the war, the French subsidised a paper called "The Future," (El Mustakbal.) At the moment the Syrian students are about to publish a periodical, written in Arabic and French, which will deal entirely with contemporary affairs in the Near East. Journalism had a vitiating effect on the prose and poetry produced during the last century, but, especially in the Lebanon, there was considerable literary activity, chiefly expressed in commentaries and criticisms of the giants of olden days. Sheikh Nasif al Yazili and Ahmed Faris al Shidyaq did good work in this way, but it was not until the national movement arose in the Arab world, that an impetus was given to original work. It is difficult to specify at what moment the religious spirit in the Middle East, which had been the dominating factor for so long gave way before the racial. During the last 20 years some of the best histories have come from Syria, and, in them, we remark a new note in which the Arab predominates over the Moslem. Besides these Rafik Bey el Azm wrote a four volume work on the Heroes of Islam, and Sheikh el Rafii, of Tripoli, compiled two magnificent volumes on the Literature of the Arabic Languages.

Jurgi Zeidan of the Lebanon, wrote, "The History of Modern Civilisation," and Emir Sheikh el Arslan, the Druse, has written a considerable amount on sociology and politics, using the simple classical style. He tried to revive the peculiar method of Ibn Muqaffa, called "sahl mumtana," easy yet difficult to imitate, in which the master wrote his Kalila wa Dimna. But it was the war which changed the whole tendency of Arab literature. The last century had proved disastrous for the Moslem world. One by one their treasured possessions had been taken from them. England, Italy and France shared in the spoils, and it looked as if a united West was bent upon despoiling an East rent by factions. The war let loose the stored resentment of the Arab world. It showed that the European nations could be played off one against another, and it broke the retrogressive doctrine of kismet. President Wilson's phrase "self-determination" was the torch which lit a flame throughout North Africa and Arabia; and King Hussein expressed the new feeling, when he asked the Christian Editor of the "Muqattam" to come and see him at Jedda with these words, "Remember that, hundreds of years ago, before Mohammed and Christ, your forefathers and mine were Arabs."

So great an upheaval of thought was bound to be reflected in Arab literature. It had perhaps been foreshadowed by the poetry of the blind Taji el Faruki, a Palestinian, who, under the tyranny of Jemal Pasha, defended the national cause and sang an awakening of the hero-spirit which had conquered the old world. From America, where so many Syrians had emigrated under Turkish rule, came a new school of writers, tainted perhaps by American journalism, but finding the motive for their patriotic and descriptive writings in the longing they felt for the Lebanon and the Hauran. Coastal Syria had benefited widely by the American colleges, where her youth had imbibed some of the democracy of the States, and this is not only reflected in the modern writings, but will doubtless influence the political future of the race. America at this moment has seventeen newspapers published in Arabic, and her Syrian and Palestinian journalists send contributions to the newspapers of a dozen Arab countries along the Mediterranean. Amin Rihani is a product of this new school, though his translations of Abul Ala have won him as much fame as his original verses. Since he has visited most of the great men of Arabia in their mountains or deserts in

furtherance of Arab unity, he will probably end by being the poet laureate of the new nation. Older men, waking to find themselves as fiercely Arab as they had once been Moslem, return as far as possible to the early traditions of style.

Thus Abd el Mehsen el Kasimi from Bagdad, a son of the desert, and used to reciting long extempore poems in praise of camp life and the virtues of the wilderness, stood up one day in public and improvised 100 verses inspired with the most fiery nationalism, but using the old "rajaz" chaunt.

Kheir ed Din Zerekli, of Damascus, has written satires and critical, pessimistic poetry after the old models, but he has also experimented with new metres.

No sermon of Ibn Nubata in the 10th century urging the jehad, or Holy War, was more forcible than the last discourse of the French-appointed Sheikh el Ulema at Damascus, Salim el Bukhari. This famous preacher, announcing that he was an old man, and that he wished his face to be white at his imminent meeting with his God, violated the stringent French instructions, and preached for several hours on the need of contributing to Arab unity by accepting the Caliphate of King Hussein. Next day he was dismissed by France. Naturally the nationalist movement has produced a quantity of contemporary historians, and the rise of the Sherifian family almost as great a host of biographers. Principal among these is Mohi ed Din el Khalil, of Damascus, who went recently to Mecca to write what should be a most interesting book—The Lives of King Hussein and his sons.

Even the unwritten Bedouin literature reflects the general feeling, and the desert Arab, varying his songs in praise of his camel and its ancestors, with rhymes concerning the great figures on his horizon, introduces the phrase "the peace of Feisul" as typifying Arab freedom.

Maruf Risafi, a Bedouin who has written many Arab songs, even produced an Arabic version of the "Marseillaise." His work is typical of the force and imagination which the Nationalist poets put into their plea for freedom. Many of them are free-thinkers, and a favourite quotation at the head of a passionate appeal for tolerance and unity is Mohi ed Din el Arabi's 13th century verse:—

"My heart has become capable of every formula;
"It is a pasture for gazelle, a convent for monks, a temple for idols,
"The pilgrims' ka-aba, the tablets of the Bible and the book of the Koran,
"I follow the religion of love- -
"Whatever way love's camels take, that is my religion and my faith."

With all these new writers we leave Arab literature in its second growth. It remains to be seen whether its final tendencies will be backwards towards the classic, or whether, influenced by Europe, its language will be modified and modernised, so that the learning of thirteen centuries will be opened to the general public. In either case its fresh inspiration should assure its future, especially as Arabic is one of the richest and most expressive languages in the world; eloquence is the heritage of the Arab races; and learning the quality most honoured among them.

DISCUSSION.

Brigadier-General Sir Percy Sykes, K.C.I.E., C.B., C.M.G., said he had hitherto known the lecturer as a very distinguished traveller, among the very greatest of our lady travellers. When he heard her give her lecture at the Royal Geographical Society on the wonderful expedition which she had led to Kufra, he marvelled at her courage. He did not think that she had brought out at this lecture one of the chief sources of her success, namely, her genius for understanding the mentality of the people among whom she travelled. She had stated in her lecture what a very important and predominating part the Arabs had played in mediæval Europe. It was known, for instance, that the Pope always kept an Arabic secretary, and that gave one an idea of the importance of Arabic. Another example was that which he had come across in connexion with his own Persian studies, namely, that when Harun-al-Rashid the Caliph exchanged embassies with the great European monarch, Charlemagne, he made Charlemagne the gift of an elephant, which was the first to be seen in Europe since the days of Alexander the Great and Pyrrhus. He had been much interested when, one day at the Victoria and Albert Museum, he had been telling the fact to the head of the department of textiles, who said, "I can tell you something more, namely, that when Charlemagne died, the robe in which he was wrapped had an elephant embroidered on it." That showed how enormously Charlemagne had been influenced by the gift of an elephant. Again in quite a different part of the world—in California—he had been much interested in seeing the saddlery and horsemanship of the Mexicans.

It was Arab saddlery and Arab horsemanship, which had reached the New World through Spain. The very largest point of view had to be taken—a point of view which the Royal Society of Arts stood for, and had stood for since its foundation. We in the West had to study the point of view and the literature of the nations of the East, and in that connexion the greatest possible credit was due to travellers like the lecturer.

MR. A. F. KENDRICK, Head of the Textile Department, Victoria and Albert Museum, remarked that nobody who had listened to the lecture would fail to see the great scope of it, its interest, its wide range of learning, and perhaps above all the wonderful experience it related of the countries about which the lecturer had spoken.

The subject of Arab art was a very difficult one to deal with. He was sure the lecturer would agree on that point. It always reminded him of a hedgehog; wherever one touched it seemed to prick. The question had first of all to be asked, What was Arab art? Was Arab art the right name for it, to begin with? The compromise which could be come to was that if it was called Mohammedan art one was on firmer ground. The contribution of the Arab had been largely a contribution of the sword. The influence upon art had been very considerable, but it was an influence derived from the craftsmen of the countries conquered by the Arab sword. He would draw attention to one or two points illustrating that aspect of the question. The lecturer wrote in her paper about the mosque and minaret at Samarra in Iraq, and of the mosque and minaret of Ibn Touloun at Cairo, and she derived both from earlier models. Maqrizi, an Arab historian, said that the mosque of Ibn Touloun at Cairo had been copied from the mosque at Samarra. and modern scholars who had seen those places and had noticed the foundations of the one and the building of the other were inclined to agree on that point. Samarra and Cairo were considerable distances apart.

Then there was another monument which came to one's mind—that great palace-façade of Mshatta in Syria, which had been removed not very long ago from the Syrian Desert to the museum at Berlin. Scholars had got to work at it as soon as it had been set up at Berlin. Some said that it was a Syrian Christian building belonging to the 4th or 5th century, and others maintained that it was a Mohammedan monument; the latter seemed to be the considered opinion of to-day—that it was actually a Mohammedan monument put up by one of the early Caliphs of Damascus in the 8th century. However, the question was not yet definitely decided. That as much as anything helped one to see the difficulty of the subject which had been discussed that afternoon.

The lecturer very rightly drew attention to the great influence of the Arab conquests upon textiles as upon art generally, and perhaps he might draw attention to two of those. She mentioned that the Fatimite art of Cairo formed a new style of its own; that style was exemplified in the Fatimite stuffs. It was known what they were like because there were dated pieces in London; but there was at Madrid a piece of stuff with the name of Hishâm the 2nd, who was the Caliph of Cordova in the latter part of the 10th century, with a pattern almost identical with some of those Fatimite stuffs, although certain indications precluded it from having been made in Egypt. Another illustration was that to which Sir Percy Sykes had referred—the shrine of Charlemagne, in which was found a wonderful stuff with an elephant upon it. That stuff had a Greek inscription showing clearly that it was Byzantine work and almost certainly made at Constantinople. Three or four years ago there had been found in the little seaside village of St. Josse near Calais, a piece of stuff in a shrine of St. Josse. That stuff also had an elephant, and besides that had many points of similarity to the stuff in Charlemagne's shrine; but instead of a Greek inscription it had an Arabic one, referring, so scholars stated, to a General in Khorasan in the second half of the 10th century. That was now in the Louvre. So one got those two similar stuffs, one with a Greek inscription pointing to Constantinople, and the other one with an inscription taking it right away almost to the centre of Asia.

The point he wished to make was that Mohammedan art was very diverse, and it was an art of many lands. One could trace almost a continuous chain of Mohammedan art from Spain right away to the South of China.

PROF. G. HAGOPIAN considered the lecture showed the glory of Englishwomen and English lady travellers in going to distant countries and associating with the peoples there in order to learn and study, with great personal danger to themselves, the local ideas and inspirations of the Arabs. It was difficult to believe that the Northern Arabs from Arabia had any ideas of art or architecture. They were very prone to transform Christian churches into mosques. The Turks were no different from the Arabs as far as principles of religion and conduct were concerned. One could not separate the ideas under which Turkey had governed for centuries from Arabic ideas, but there was one difference, namely, that whereas the Turks studied Arabic literature, the Koran and jurisprudence, they despised the Arabs and dominated them. Now the wheel had turned. The Arabs were finding their freedom, and judging from the papers published in the United States of America, the future of Arabia would be a different one from that of the past, however the Arabs might copy more Eastern ways of expressing themselves.

LORD LAMINGTON, G.C.M.G., G.C.I.E., in proposing a vote of thanks to the lecturer, said it required an intimate knowledge of the subject to deal with an essay such as Mrs. McGrath had read. The Royal Society of Arts was deeply indebted to her for a lecture which had meant immense knowledge and research on her part. It was doubly valuable, because it was not the outcome

only of research and examination of books and libraries, but also the outcome of her remarkable travels and her personal acquaintance with the countries mentioned. She knew the characteristics of the peoples of those countries and had been able to gain experience of the life and habits of those who were connected with the great literature and art of the Arab peoples. He thought, therefore, the lecture would stand out as a monument of learning.

THE CHAIRMAN (Lord Askwith), in seconding the vote of thanks, said that the lecturer had introduced a very interesting subject, and one which was of great future importance. The Arabian movement, as he called it, or the Mohammedan movement, as Mr. Kendrick preferred to style it, was one of those curious movements in the world which fascinated man, and also affected millions of human beings. History had yet to show how it had really arisen, but it had come from a central movement in the midst of very ancient countries, each with its own history and great riches (which certainly must have proved an attraction to the Arabs when they had first commenced) and with little or no belief in any particular thing, except in the lands where Christianity was still a struggling movement. It had come with a great cry of Mohammedanism which had appealed to men's minds and which had appealed also to many ancient beliefs. They went forth with the cry "There is but one God and Mahammed is his prophet." Naturally a comparatively small number of people with the sword in their hand, and with no knowledge of great buildings, could not, unless they had taken with them the peoples of the countries where they went, have had such an immense influence upon such vast territory. They adapted the Christian Church of Sta. Sophia, or temples in other parts to their own purposes. They used in Egypt the columns of the Roman period. They covered them to a certain extent with what they knew of themselves, skill of decoration, beauty of colour and a most extraordinary varied intricacy of design, and they had a certain cohesion in their vast territories by means of the religious element. But each portion of it broke away and had in subsequent times a history of its own. Spain was very different from Iraq, Iraq different from Persia, and one found, although one or other of those divisions might have become prominent in a particular kind of art and impressed itself upon the rest, that each had its own history. As the lecturer had pointed out, the confines of that vast Empire perhaps might exercise enormous influence on the adjoining lands. The Abbassid dynasty came and impressed itself with Persian views upon Iraq, even while the Arabic was still very prominent in Persia. So in Spain, the Christian religion dominated there after struggles which lasted for so many centuries. So it was that there came a time when there was not so much cohesion, but when those divisions were working upon their own. Through all that period one interesting thing was how those people, singing of their own deeds, writing histories of their own deeds, brought together a desire of poetry, and of history, and, in order to obtain a common law, of jurisprudence, and in each art or profession produced some very remarkable men. All those things must have had their origin before—particularly poetry. As the lecturer pointed out, poetry even survived Mohammed, who condemned such work as idolatrous, and ordered various contemporary poets to be executed. Yet the Arabs went on with their poetry and the poet turned Mohammed into a sort of God to be praised, and the historian into one of whom their books were to be written. It might have been that a further cohesion might have arisen through the philosophical writers if a puritanical movement or a Mohammedan new movement had not come to overthrow the adoption by the Arabs of the greatest of them, and it might have been that possibly the idea of magic might have spread—a remnant as it must have been of the worship of some of those tribes in previous days. But the Ottoman Turk came and there seemed to come a cessation of the prominent Arab movement. It had now awakened again. We were seeing it before us day by day. We should see it in the next few score years still more powerful, and it would be a movement undoubtedly coloured by the influence of those Arabs and cognate races who had emigrated to the New World, and who still retained their love of the desert and of the old. They had newspapers and writings poured forth in America and pouring forth even now in Europe. Whether the New World could come to redress the balance of the Old as regarded Arabia remained to be seen.

NOTES ON BOOKS.

THE LONDONER'S EDUCATION. London: Hodder and Stoughton, Ltd. 9d. net.

This popular handbook is one of a series on the work of the London County Council and what it does for London. Whoever conceived the idea of the series is to be warmly congratulated, for the ratepayer will certainly pay his rates more readily after glancing at this booklet than he has ever done before. If any one is inclined to grudge the money spent in London on education, let him read these extracts from official reports made before elementary education was made compulsory:

"The streets were swarming with waifs and strays, who had never attended school, a large number of whom habitually frequented the riverside, the London railway termini, the purlieus of Drury Lane and Seven Dials, streets and corners off Holborn and the Strand, and the neighbourhoods of the Borough, Whitechapel and many similar parts of the Metropolis. The children slept together in gangs in such places as the Adelphi Arches, in empty boxes or boilers, at Bankside in empty packing cases, down the 'Shades,' covered with tarpaulins and old sacks."

"The children's lives were a constant round of sunless drudgery—they never played as children play, they never seemed to think; they were prematurely old, and the victims of an awful cruelty. . . Their mortality was high."

Let him contrast this dreadful state of things with what he will find described in this handbook—bright and cheerful schools, and happy children learning not only lessons but, what is almost equally important for them, games that teach self-control and team-work, and then let him consider whether the cost of the change is too high. That it is high no one can deny. The London County Council's education service costs annually £12,600,000; it employs 30,000 teachers and officials; but it educates 1,000,000 people. Last year the youngest child at school was scarcely two years old—a baby in a nursery school; the oldest student at school was 78—a grandmother and a keen student at a women's institute.

A fair idea of the way in which the money is spent will be gained from this handbook, which tells briefly what is being done in the elementary and central schools, in the special schools for the afflicted, the arrangements for the physical care of the children, and for technical education and lastly how with the aid of scholarships clever children may find their way to secondary schools and thence to the universities.

THE WORLD'S COTTON SUPPLY.*

By Sir Charles W. Macara, Bt.

Everyone should be interested in rescuing the largest of our manufacturing and exporting industries from the disastrous position into which it has fallen, mainly through lack of vision in dealing with the conditions brought about by the world crisis through which we are passing. The outstanding fact, is that we must have more and cheaper cotton, and, further, we must not rely on America for our supplies to the same extent as we have done in the past.

The Cotton Crop Reporting Mission, sent to America last year by the International Cotton Federation, pointed out that the cotton States east of the Mississippi are no longer able to supply cotton on an economic basis which will enable Lancashire to supply the normal quantities of cotton goods to the agricultural populations of India and China, "inasmuch as agricultural produce in these countries is being sold at or near pre-war prices, while American cotton is above 200 per cent. of the pre-war rate."

The conclusion the Mission arrived at was that America would not be in a position to supply cotton at a cheap rate for years to come, if at all, and that America, in any case, has now not the least chance of competing with British possessions or with countries like Brazil, Peru, etc., in the raising of cotton.

*Abridgment of article in the *Financial Times*.

The Mission does not expect more than about 9,500,000 bales to be raised in America in any normal year in the future. When it is remembered that American mills are now using 6,250,000 bales a year of their own cotton, with every prospect of increasing that quantity, it will be seen that there can be little left for the rest of the world in coming years.

Personally, I consider this estimate of future American crops to be somewhat pessimistic, but it shows, at all events, the urgency there is for the growing of more cotton both in the British Empire and elsewhere.

It is only since the International Cotton Federation began to turn its attention to India that the possibilities of that country have been fully realised. As showing what can be done there, it is but necessary to point out that the Indian cotton crop was raised from 3,000,000 to 6,000,000 bales in the ten years before the war, and had not the war intervened it was estimated that it would have been possible in a very short time to raise the crop to 10,000,000 bales of 400 lbs. each, which is in the neighbourhood of the total crop America has been raising in recent years.

A small proportion of the Indian crop has hitherto been found suitable for the mills of Lancashire, but Indian cotton is suitable either for the Far East or the Continent of Europe, and those who buy it leave so much more of the better qualities for the English market. The production of countries outside America is steadily improving. and Lancashire is finding it possible to use more and more of these "outside growths." While the import of growths other than American into Great Britain was but 26 per cent. of the whole in the 1920-21 season, the daily trading at Liverpool last year showed that British spinners were taking 50 per cent. of non-American growths.

What is known as "American" cotton is not indigenous to America, and can be grown where the soil and climate are suitable. In India, for example, the Government Departments of Agriculture are now taking the keenest interest in promoting the cultivation of improved varieties of cotton, and the Punjab alone is expected to increase its crop of cotton grown from American seed this season by something like 50,000 bales. Not very long ago Lancashire's takings of Indian cotton were comparatively small, but, according to Liverpool Cotton Association figures, the imports into England of Indian cotton from 1st August, 1923, to the middle of February, 1924, totalled 138,711 bales, and practically the whole of this cotton went to Lancashire mills. The products of Brazil, Peru and other countries are being used in Lancashire more and more.

Magnificent strides are being made in the Anglo-Egyptian Sudan, where all records in production, it is expected, will be eclipsed this year; much progress is being made, also, in India and elsewhere, and new fields are opening up in all parts of the Empire where cotton growing is possible; but, apart from these enterprises, we see signs of

development in almost every part of the globe where cotton can be grown.

Meantime, it is to be hoped that while we are improving our supplies of the raw material we shall cease to scramble for the limited trade that is coming to us from abroad, and especially from the Far East, under present conditions, and that we shall take steps to control our output scientifically and cease to ruin ourselves by senselessly competing for the greatly reduced volume of business available.

VICTORIA AND ALBERT MUSEUM.

The Victoria and Albert Museum has acquired two important pieces of English furniture from the collection of the late Colonel H. H. Mulliner, given by Mrs. Mulliner in his memory. One of the objects consists of a small commode of serpentine shape, enclosed with folding doors, veneered with satinwood and rosewood, and decorated with festoons and trophies of musical instruments inlaid in other woods. The angles are fitted with finely modelled mounts of gilt metal. This type of furniture was made by Chippendale and other English cabinet-makers about the year 1770, and follows to a certain extent the French style of Louis XV., with which it may not unjustly be compared for excellence of workmanship.

The second object is a small dressing-table of the same period, also veneered with panels of satinwood and inlaid with classical vases, festoons, foliage, etc., in woods of various colours. The table is of ingenious construction. The drawer in front, which contains a mirror and two receptacles for toilet articles, can only be partially pulled out until it is released by sliding back the top of the table. The lids of the drawers are inlaid with heads of a man and woman in Eastern costume. The feet are mounted in brass, chased and gilt.

These objects are at present temporarily exhibited in the West Hall of the Museum.

In the same Court has now been placed on exhibition a typical shop-front from No. 32, Petty France, Westminster, a locality which for eight years was the dwelling place of Milton. This shop-front, which was handed over to the Museum by the War Office at the time of the recent demolition of houses in this street, is of pinewood, and the bow window is supported on iron brackets and surmounted with a cornice, enriched with finely modelled egg-and-tongue and leaf ornament. The period to which it belongs is that of the second half of the 18th century and it represents a class of domestic architecture which is now fast disappearing.

GENERAL NOTES.

Conference on Illumination.—A Conference on Illuminating Engineering will take place at the British Empire Exhibition on August 12th. A report of the proceedings at the meeting of the International Illumination Commission and at the First International Conference on Industrial Hygiene, recently held in Geneva, will be presented, and developments in connexion with the lighting of schools and factories will be discussed. The other subjects to be considered include public lighting and the lighting of exhibitions. A paper entitled the "Illumination of Highways from the Motorist's point of view" will be read by Mr. Edward H. Fryer (Roads Dept., Automobile Association), and Mr. Haydn T. Harrison will deal with some features of the lighting of exhibitions. The Conference will be open to all interested in the subject of illumination, and tickets can be obtained from the Hon. Secretary of the Illuminating Engineering Society, Mr. L. Gaster, 32, Victoria Street, S.W. 1.

Reclamation of the Zuyder Zee.—In his recent report on the financial, industrial and economic conditions of the Netherlands, the Commercial Secretary to H.M. Legation at The Hague states that the preliminary work on the reclamation of the Zuyder Zee was continued during 1923, efforts being concentrated on the tract between Weiringen and the mainland. Boring was continued in order to arrive at the most suitable position for the main dam, but no definite steps were taken to begin this work. It should be borne in mind that since the original estimate was made conditions have changed. Although prices of material required in the reclamation may have declined as well as those of labour, which was one of the reasons why at one time abandonment of the plan was urged, it is feared that, now prices for agricultural produce may decline further, the land reclaimed cannot be profitable exploited.

Gum Copal from the Philippine Islands.—Although there are many hundreds of grades of gum copal, varying according to colour and size, there are two major divisions—the copal that is taken from the ground, where it has lain possibly for centuries and become solid, and that which is tapped from the trees and is softer and not so desirable for making varnish. According to the United States Trade Commissioner at Manila, the gum reaches Manila through Chinese channels, where it is sold to exporters. It arrives in a very dirty condition, and the expense of cleaning and grading, as well as the inland transportation, constitutes a large portion of the export price, Philippine gum copal is not favourably regarded in the American market. Much of it has been shipped to Singapore. German firms, re-established in Manila since the war, however, have placed considerable quantities in the United States.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.2.

NOTICE.

COMPETITION OF INDUSTRIAL DESIGNS.

The Exhibition of selected works submitted at the Society's Annual Competition of Industrial Designs is now being held, by the courtesy of the Director, in the North Court of the Victoria and Albert Museum, South Kensington, S.W., and will remain open until Saturday, August 30th. The designs exhibited are divided into the following classes: Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. The Exhibition is open to the public free daily from 10 a.m. to 5 p.m., and on Thursdays and Saturdays from 10 a.m. to 9 p.m.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

MONDAY, 16TH JUNE, 1924.

SIR RICHARD REDMAYNE, K.C.B., M.Sc., M.Inst.C.E., M.I.M.E., M.I.M.M., F.G.S., Chairman-Governor, Imperial Resources Bureau, in the chair

THE CHAIRMAN, in introducing the reader of the paper, said Dr. Corless's knowledge of his subject was exhaustive. Not only had Dr. Corless a distinguished career at the McGill University, being the holder of several very high academic honours, but he was a thoroughly practical mining engineer and metallurgist.

The paper read was:—

MINERAL WEALTH OF THE PRE-CAMBRIAN IN CANADA.

By C. V. CORLESS, M.Sc., LL.D.,
Director and Manager of the Mond Nickel Company, Limited.

I.—INTRODUCTORY.

Canada is a country of vast area. It is slightly larger than the mainland of Europe; roughly 25 per cent. greater in area than either the United States or Australia; more than 70 times as large as England; and nearly equal to one-third of the pre-war British Empire. It is not surprising that the relative importance of the various natural resources of so vast an area is being revealed but slowly, even to Canadians. It is still less surprising if their relative extent is almost unknown in Great Britain.

History has contributed not a little to this failure to grasp the relative value of the resources of this half of North America. In the early settlement of the continent Spain occupied the southern third in latitude; Britain, the east coast of the middle third; and France, astride the great waterway leading to the heart of the continent, claimed possession of the northern third. But Britain, in persistent search for a shorter route to the land of silks and spices, explored and took possession of a great region of furs. The extraordinary commercial success of the Hudson's Bay Company, at the same time that it enriched its shareholders, stamped Canada as a land of snow and ice; and first impressions are most enduring. Nearly a century of petty rivalry followed between the fur-traders on the St. Lawrence and those on Hudson Bay, and then this local strife became an insignificant side issue in the world-wide maritime and colonial struggle between Britain and France, which ended by laying the foundation of the British Empire in Canada and in India. Not less really, though perhaps more obscurely, the foundation of Modern Germany—and so, of the late German Empire—was laid at the same time, by the steadfast resistance of Prussia, under Frederick the Great. Thus was unconsciously effected the transference of rivalry which has culminated in world-wide disaster a century and a half later. But, if Britain in this struggle won a half continent, her attempt to share part of the cost with the neighbouring colonies soon lost her the other half. Thus a decision, which was of slight inherent importance,

but which contravened a great principle, became a turning-point of vast import in history.

The fight for American Independence, of which this unwise decision was the occasion, if not fundamentally the cause, gave rise to a considerable emigration of loyalists into southern and eastern Ontario, two of the three greater plains of fertility in Canada, and thus confirmed the growing view that Canada is essentially agricultural. Finally, with the consolidation of the scattered provinces of Canada into a confederation, a half century ago, a physical bond of union became a necessity, if the partnership was to become more than a name, and, for so young a nation, the herculean task of constructing a trans-continental railway was undertaken. This railway, the justly famous Canadian Pacific, opened up for settlement, at its widest part, Canada's largest northward extension of the great central continental plain—a wheat-growing territory second to none in the world. Now in London, of all places in the United Kingdom, the fact is ever before you that Britain is a small island, heavily over-populated as a result of the recent industrial revolution, and therefore a great importer of foodstuffs. What more natural than that the crowded population of Britain, seeing Canada's exportable surplus of wheat leap upward by the hundred million bushels, should fix attention on Canada's agricultural areas, and should form a view of their relative importance out of proportion to the actual geographic, physiographic, and geologic conditions ?

Furs, timber, farm products—these in natural order of development, as well as in ascending order of importance, have come to be regarded as Canada's greatest natural resources. The visitor to Canada from abroad, making his stay at Montreal, Toronto, or Winnipeg, situated respectively in the three northward extensions into Canada of the great central continental plain—that vast expanse of fertile lowland stretching northward from the Gulf of Mexico—not realising that at or near the Canadian boundary this northward-expanding area suddenly shrinks, readily accepts the prevailing view that Canada is, and will remain, first of all a land of fertile farms. If, reflecting on the limitation of his own observations, he turns to the article on Agriculture in Canada in the *Encyclopædia Britannica*, he will find that the impressions created by the immigration literature he may have seen before sailing are confirmed by the opening statement: "Canada is pre-eminently an argicultural country." But, if he makes a real study of the country, it will come as a rude shock when he discovers that because of recent glaciation, mountainous surface, or climatic conditions, not more than about 15 per cent. of its entire area is suitable for profitable cultivation.

II. The Agricultural Part of Canada.

But, lest your minds be carried too far in the opposite direction, I hasten to add that only about one-third of this area has up to the present been brought under cultivation. This 15 per cent., though a relatively small part of Canada, is yet more than ten times the area of England; it comprises about 350 million acres. It is about one-third of the area of land suitable for cultivation in the United States. Setting aside one-seventh of this area for roads, railways, towns, cities, villages, and other conveniences and necessities of civilisation, this cultivable area will easily support a farming population of 15 millions with profit and without discomfort, if we allow 100 acres as the average farm unit, and assume the average rural family to be five. This might easily be the rural basis of a national population of 50 or even of 75 millions.

III. The Non-Agricultural Part of Canada.

What of the remaining 85 per cent. of Canada ? It would be a matter of great interest, had we time to consider Canada's timber resources and great mineral possibilities as a whole, not forgetting her resources in coal and lignite, estimated by geologists to exceed the total fuel reserves of Europe by 60 per cent., and to be probably 75 per cent. of the solid fuel resources of the entire British Empire. But we shall do better to confine our attention for the time at our disposal to Canada's vast pre-Cambrian area, the greatest physiographical and geological feature of the country, to which is chiefly due its agricultural limitations, and which is the fundamental cause of many of Canada's most serious national problems. It is this vast feature which, eastward from Winnipeg, blocks the extension northward of the great central North American plain, confining it to two small, though important, farming areas:

southern Quebec and the southern tip of Ontario. It is this also which narrows the largest extension of this plain northward into Canada to a wedge-shaped area, having a base of less than 800 miles at the international boundary and tapering to a mere valley between the pre-Cambrian and the Cordilleran highland of the Yukon, along the lower reaches of Mackenzie River, well within the Arctic Circle. It is this pre-Cambrain area, popularly known as the Laurentian Highland, equal in total area, to 60 per cent. or more of Canada's mainland; so little known; so misunderstood; hitherto, generally regarded as a "barrier" or a "wilderness" to be crossed in order to reach Canada's western plains; so great a source of the nation's economic, social and political problems; to which I wish to invite your studious attention for the remainder of this discourse.

IV. Outline, Form, and Extent of the Pre-Cambrian.

If you have ever sailed to Montreal via the St. of Belle Isle, passing to the north of the island of Anticosti, as the steamships occasionally do, you obtained a first glimpse of the pre-Cambrian on entering the strait, and followed its bold and rather forbidding shore line for 800 miles, to a point a few miles east of Quebec City. From this point to Montreal, its southern rim is never more than 30 miles from the north shore. For about 1,000 miles, strait, gulf and river may be considered as marking the contact between rock formations of this most ancient geological era, and those of more recent eras. If from Montreal you follow the Ottawa tributary of the St. Lawrence westward for about 175 miles, you will observe from the window of the Canadian Pacific Railway train, the rim of the pre-Cambrian Shield following the opposite shore of the river, which, for this distance, marks the contact. Then turning abruptly southward you will follow the irregular contact across the narrow eastern extension of Ontario, of rather less than 5,000 square miles, lying between main river and affluent, and cut off geologically from the larger southern plain of the province by this south-eastward spur of the pre-Cambrian. This triangle of farming land in eastern Ontario and the fine fertile area in southern Quebec, passed to your left as you ascended the St. Lawrence from Quebec City to Montreal, constitute together the first of the northward extensions into Canada of the central continental plain, already alluded to, comprising between 15 and 20 thousand square miles. The pre-Cambrian spur crosses the St. Lawrence, forming part of the beautiful "Thousand Islands," at the outlet of Lake Ontario, and spreads out over an area of roughly 10,000 square miles, forming the Adirondack Mountains of New York State.

Continuing our circuit around the Canadian Shield, we follow the St. Lawrence across the neck of the Spur for 40 or 50 miles to a point near the city of Kingston, and from this city proceed nearly due westward to Georgian Bay, a distance of about 175 miles in a straight line. To the south and south-west of this line lies the second of the extensions into Canada of the continental plain — the arrow-head peninsula of southern Ontario; nearly surrounded by the three Great Lakes, Ontario, Erie, Huron, and their connecting waters; and comprising about 25,000 square miles of very fertile and highly developed farming land.

Small as these two northward extensions are, their combined area being about two per cent. of that of the Canadian Shield, or slightly over one per cent. of Canada, they yet contain probably half of the present total population of the country, with ownership or control of more than half of its developed wealth.

From the point at which we reached Georgian Bay, the outer rim of the Canadian part of the pre-Cambrian Shield follows the shore line of the bay and the two Great Lakes, Huron and Superior, to the intersection of the latter shore with the international boundary, thence this boundary to a point ten or fifteen miles west of the boundary between Ontario and Manitoba. Turning north-westerly the rim continues for about 425 miles in nearly a straight line, sixty per cent. of which coincides with the eastern shore of Lake Winnipeg. At a point about 50 miles north of this lake, the outer contact of the Shield turns sharply to the west, crosses the province of Saskatchewan, and again curving with a wide sweep more north westerly, clips a corner of about 2,000 square miles off the most westerly prairie province, Alberta, the province which contains about 70 per cent. of the Empire's estimated coal resources. Of the three so-called prairie provinces, the pre-Cambrian Shield occupies roughly two-

thirds of Manitoba, one-third of Saskatchewan and this corner of Alberta.

From the intersection of the outer rim of the shield with the 60th parallel of north latitude, 600 miles west of Hudson Bay, the outer contact of the pre-Cambrian continues north westerly for 800 miles, nearly to the Arctic Ocean, including in the Shield roughly one-half of the great marginal glacial lakes, Great Slave and Great Bear, each of which is about 50 per cent. larger than Lake Ontario, on which Toronto is situated. This last 800 miles is in the mainland part of the unorganised North West Territories. of which the pre-Cambrian occupies roughly two-thirds, or about 500,000 square miles.

The pre-Cambrian also occupies the southern or south-eastern parts of some of the large islands in the Arctic Archipelago, north of Canada, to the extent perhaps of 200 or 250 thousand square miles, though naturally this area is not yet accurately known.

From the most north-westerly point of the Shield, near the Arctic Ocean, only about 400 miles from Alaska, and therefore almost in the extreme north-west corner of Canada, the distance to the entrance to Belle Isle Strait, measured in a straight line, is 2,500 miles, divided equally by the broad 350-mile opening into Hudson Bay, which, with its northern extension of 350 miles, Fox Channel, and its southern extension of the same measurement, James Bay, has a total length of 1,300 miles, a maximum width of 600 miles and a total area of more than twice that of the North Sea. This large mediterranean sea, penetrating to the heart of the Shield, imparts to its inner rim the appearance of a great horse-shoe ; the outer rim, which we have traced, is somewhat similar to a wide V, each limb being more than 1,500 miles in length, and the roughly truncated angle pointing southward.

A broad and clear view of the greater facts connected with the geographical position and extent of this vast physical and geographical feature is so essential to a proper understanding of Canada that, even at the risk of wearying you, I am tempted to present these greater facts from a slightly different angle.

Approaching Canada from the west we come first to the very mountainous Cordilleran Plateau, or Pacific Highland, averaging 400 miles wide, stretching about 1,500 miles from the international boundary to the Arctic Ocean, and comprising British Columbia, Yukon territory and a narrow adjacent strip in Alberta and North West Territory. This highland we may consider as approximately 600,000 square miles in area.

Next eastward we come to the greatest of the three northward extensions of the central continental plain ; roughly wedge-shaped, with the base somewhat less than 800 miles wide at the international boundary, measured from near Winnipeg to the Rocky Mountains ; tapering northwestward and reaching the Arctic Ocean in about 1,650 miles ; narrowing to 400 miles or less at 60° north latitude, the boundary between the four western provinces and the two northern territories ; and finally contracting to little more than the valley of Mackenzie River. The southern part of this extension of the central plain comprises easily 70 per cent. of Canada's total area suitable for profitable cultivation. The area of the whole extension is about 650,000 square miles.

The eastern boundary of the plain is the vast pre-Cambrian Shield, occupying 85 per cent. of the entire surface of Canada east of the marginal lakes between plain and shield, Great Bear, Great Slave and Winnipeg. The remaining fifteen per cent. comprises : (1) a narrow area along the Arctic coast stretching westward from Coronation Gulf ; (2) a belt of later formations (Ordovician, Silurian and Devonian) lying south and west of James Bay and south of Hudson Bay, covering roughly 100,000 square miles, of which three-fourths is in Ontario and one-fourth in Manitoba ; (3) the two parts of southern Ontario, about 30,000 square miles ; (4) southern Quebec, about 40,000 square miles ; (5) the three maritime provinces, totalling a little over 50,000 square miles ; and (6) a few small remnants of later formations within the Shield, of probably negligible area. Thus, while the Shield fills about 1¾ million square miles of all the mainland of Canada lying to the east of a line stretching north-westerly from near Winnipeg to a point within about 400 miles of Alaska near the Arctic Ocean ; there remain in all this great eastern part of Canada, exclusive of the pre-Cambrian, only the relatively small areas mentioned ; and even of these only southern Ontario, southern Quebec and the Maritime Provinces, totalling in all about 120,000 square miles, account for most of the history of the country from its discovery down to 50 years ago. Sum-

ming up, we see that this vast physical and geological feature fills two-thirds of the mainland of the North West Territories; a corner of Alberta; one-third of Saskatchewan; two-thirds of Manitoba; three-fourths of Ontario; and nearly ninety-five per cent. of Quebec. The only provinces untouched by it are British Columbia and the Maritime Group.

Now, the Pacific Highland and the three northward extensions of the continental plain, as well as the Appalachian extension into south-eastern Quebec and the Maritime Provinces, are all continuations into Canada of the three great physical features filling nearly the entire surface of the United States. In most places the dividing line is merely a survey line. The development of each of these in Canada has shown the the assimilating effect of this relationship, in some cases very strongly. The one distinctive physical feature of Canada, and that, too, of the vast area and in the important geographical position we have outlined, the feature which has in its development the possibilities of making the Canadian nation really different from, and therefore more valuable to, the American nation, but the feature which, until very recently, the Canadian people have almost ignored or regarded as an obstruction to their progress, and which is even yet inadequately known and appreciated; this unique feature is the pre-Cambrian Shield.

It would be a matter of much interest, if time permitted, to trace the effects of glaciation over this great area; to depict its low smoothed and rounded hills of bare rock, frequently bearing striations not yet weathered out, resulting from the slowly moving ice-sheet; to examine the demoralised drainage, left, on the final retreat of the ice northward, in the form of myriads of crystal lakes, numberless streams and rivers with countless rapids, cascades and waterfalls, and innumerable peat bogs and muskegs; to note how, here and there, temporary damming by the ice during its last retreat created equally short-lived or temporarily extended lakes, in some places of considerable extent, on the beds of which glacial silt prepared the future surface for farming; to observe the dribble of drift left as a mantle over much of the surface as the ice made its last retreat before the brief period in which we are living; to study the farming and forest resources of the area—the former extending over perhaps 10 per cent. of the southern fourth of the Shield and the latter over roughly the southern third; to estimate the economic value of the disorganised drainage in the developed and potential water-powers, in the facilities afforded for transporting logs to the numerous lumber, pulp, and paper mills, and in the scenic and sporting possibilities created in the area; to consider the climate and to outline the general geology of this great area. But we must confine our attention almost exclusively to the immense potential mineral wea'th of the pre-Cambrian, made possible of discovery by the removal through glaciation of the deep covering of decayed rocks and soil which must have accumulated through ages of weathering, noting any of these other interesting matters only in so far as such references will cast light on the mineral wealth of the Shield.

V. Some Fundamental Principles Necessary in Estimating Mineral Wealth.

When we study a vast territory such as this, much of it remaining practically unexplored, and of the remainder, only a few square miles here and there exhaustively searched for economic minerals, we shall miss our main object if we fix our minds on achievement, rather than on what past achievement signifies. The use of well-balanced judgment, in conjunction with inductive and deductive reasoning, is an absolute necessity, if the future possibilities of so great a territory are ever to be grasped. For most mineral resources differ in a very important respect from land and forest resources. They must be discovered; and discovery is generally an uncertain and costly undertaking, even after the assistance of the prospector is accepted in finding the first clues.

The search for minerals in a well mineralised area is a class of enterprise which generally can be converted from mere gambling into a serious business, by taking sufficient chances to eliminate the chance of total failure. On the average, hundreds of mineral claims must be examined, dozens trenched and sampled, and many tested by drilling or other costly work, for each discovery of an ore body that will develop into a flourishing mine. But the use of experienced judgment, based on accurate observation and clear reasoning, and backed by sufficient technical knowledge, energy, persistence, and financial resources,

is the only sure means for converting into sound business what would otherwise amount merely to taking a gambling chance.

VI. The Pre-Cambrian Iron Ore Areas in the United States.

In making our imaginary trip around the outer rim of the Shield, we noted a spur from the main area into New York State. When we followed the shore of Lake Superior, and later the international boundary, to Manitoba, we crossed a second projection of the pre-Cambrian into Michigan, Wisconsin and Minnesota States. The former spur is said to contain very large reserves of iron ore, figures of more than 1,500 millions of tons being given for these. But the latter, to the south and west of Lake Superior, contains the deposits known as the Lake Superior Iron Ores, which have given the United States a lead so great that in several recent years that country alone has produced more than half of the world's total output of both pig iron and steel. For many years more than 80%, and in some years close to 90%, of the total output of iron and steel in the United States has been obtained from the reduction of Lake Superior ores. For the past 10 years this district has produced an annual average, in round numbers, of 50 million tons of iron ore. The total production for the district to date is above 1,100 million tons of ore, and it has been estimated that double this tonnage remains in reserve. In addition to these reserves of iron ore of suitable grade for direct smelting, there remain, practically untouched, enormous reserves, estimated by well-known iron ore geologists at an almost unbelievably large figure, about 70 thousand million tons, of lower grade ores, which will require beneficiating before smelting. This problem is being attacked on a large scale at the present time by a group of distinguished American mining engineers, some of whom have been highly successful in other very large low-grade mining enterprises.

We thus see that this small projection of the pre-Cambrian (not more than 2 or 3 per cent. of the area in Canada) has been, and will long remain, the very foundation of the enormous industrial expansion of that famous manufacturing region, comprising less than one-eighth of the area of the United States, containing not far from half the population, much of it crowded into a score of great cities, in a dozen of which dwell more than 20 million people—a quadrilateral whose western limit is the Mississippi River from the Twin Cities to St. Louis, and whose eastern boundary is the Atlantic seaboard from Boston to Baltimore—the greatest hive of prosperous industry, the home of the most intense energy and of the largest scale enterprise, and the seat of the greatest concentration of wealth the world has ever known. Great as this remarkable quadrilateral might otherwise have been, there is no denying that the very key to its present inestimable importance is to be found in the vast deposits of iron ore in that relatively small corner of the pre-Cambrian, south and west of Lake Superior.

VII. The Pre-Cambrian Copper Mines in Michigan.

But the iron resources of this enormously productive mining area are only a part of its mineral wealth. The most northerly part of Michigan, the Keweenaw Peninsula, projecting like a finger to the centre of Lake Superior, contains the famous Lake Superior copper deposits, which have been systematically mined for 75 years. These deposits of native copper during the past quarter of a century have produced nearly 5,000 million pounds of the highest grade copper marketed. For the sixteen years prior to the post-war slump in 1920, their average annual production was 220 million pounds; and for the past 20 years, including the recent four years of severe curtailment, their annual production has averaged approximately 200 million pounds. The proven ore reserves remaining are very large, and the possibilities of discovery of additional reserves in the so-called copper range, both at greater depth and along the range, are said, as a result of recent geological researches, to be very great.

True, the Lake Superior iron and copper deposits are not in Canada. But, in seeking to interpret so vast an area as the pre-Cambrian in Canada, about the greater part of which very little is known in detail, there is every reason for accepting information regarding any part of the Shield, no matter what its source. The more intensive examination and development of the smaller areas in the United States, even though the two projections from the Shield into that country total only about 3 per cent. of the part in Canada, will broaden the basis of our later inference very materially.

VIII. The Pre-Cambrian Mineral Area North of Lake Huron.

Having fixed in our minds a few of the outstanding facts regarding the iron and copper resources of these pre-Cambrian areas in the United States, let us next consider, as fully as time will permit, the mineral discoveries and mining developments in this area in Canada.

Boarding a train on the South Shore Line south of the Copper Range, we may profitably pause, after a 250-mile run eastward, at Sault Ste. Marie. The canals, Canadian and American, constructed at this point to take shipping past the drop from Lake Superior to Lake Huron, during the 7 or 8 months' season of navigation, pass three times the tonnage annually taken care of by the Suez Canal. The greater part of this freight is iron ore from Lake Superior ports en route chiefly to Lake Erie ports, to supply the blast furnaces from Detroit to Buffalo and those of the Ohio Valley, centering largely on Pittsburg.

Again boarding an east-bound train on the Soo Branch of the Canadian Pacific Railway, we pass through an area widely mineralised with both gold and copper. Many claims of each have been staked and a few have been worked in a comparatively small way with moderate success. The copper ore is generally chalcopyrite in quartz veins, entirely free of gold or silver, or with mere traces of these metals. The company with which I have been associated for 20 years, the Mond Nickel Company, has used many thousands of tons of these ores, partly purchased from various producers on a small scale, and partly taken from the old Bruce Mines, which it owns, as flux for the iron in the copper-nickel bessemerising process, the copper of the flux being recovered incidentally in the bessemer matte. It is quite possible that the ore from some of these quartz-copper properties may successfully be concentrated at some future time, the ore or the concentrate being sold to a custom smelter. But there is no immediate prospect of this. There are also many gold prospects, some well worthy of examination, but only a few have produced gold even in a small way, the most important being Shakespeare Mine near Webbwood, and Long Lake Mine, about 15 miles south-west of Sudbury, both now closed down.

IX. The Pre-Cambrian Nickel-Copper Area at Sudbury.

At about 160 miles due east from the "Soo," we come to the thriving town of Sudbury, which, at first a railway town, provided a name for the famous copper-nickel area. The three smelters treating these ores are all located within a few miles of the town. The first discovery of ore in this area was made in 1883, during the construction of the main line of the Canadian Pacific Railway.

The more conspicuous outcrops of ore in the district were soon discovered, and later geological work showed that they are all closely associated with an intrusive rock known as norite. The great body of this intrusive was found to be a boat-shaped laccolith, about 40 miles in length and 15 miles in width, its longer axis lying at about 20 degrees north of east, the bow pointing south-westerly. The laccolith, which is considered by geologists to be a Keweenawan eruptive, was found to vary in thickness from about 1½ to 4 miles, the lower contact generally resting on igneous rocks, and being more basic than the upper. The upper, or acid edge of the eruptive surrounds a basin enclosing strata, totalling nearly two miles in thickness, of pre-Cambrian sediments, laid down during the Animikie epoch. From the outer or basic edge there branch off a number of dykes or offsets of norite, cutting through the surrounding formations for distances up to 8 or 10 miles. The numerous ore-bodies of the district are of two general types—those at or near the lower contact of the laccolith known as contact deposits, and those found in or along the norite dykes known as off-set deposits. The ore-bodies vary from a few few thousands to many millions of tons. The largest has not been exhaustively explored, but has close upon 50 million tons of ore indicated by diamond drilling.

In the 40 years since the first discovery was made approximately 17 million tons of ore has been mined, and 1,500 million pounds of nickel and copper has been recovered by the smelters in the form of Bessemer matte produced for refining. Reserves of about 100 million tons of ore have been indicated by development and diamond drilling. There are almost certainly bodies of ore not yet discovered, and some of the mines are sure to produce large tonnages of ore below the depth to which

drilling has reached. Very few have been drilled to a greater depth than 1,200 feet, and none deeper than 2,500 feet. The above estimate of reserves is therefore very conservative, and will probably be greatly exceeded when it becomes necessary to examine the district more exhaustively, a generation or so in the future.

Besides the nickel and copper contents, the ores contain minute quantities of the precious metals (gold and silver) and of the rare metals of the platinum group (platinum, palladium, rhodium, ruthenium and iridium), all of which are recovered by two of the three refining processes in use.

These mines have for years supplied 80 to 90 per cent. of the world's nickel, and, unless consumption increases to an unexpected extent, are capable of doing so for a long future. The district as a whole stands well up in the first rank of the world's great metalliferous areas.

Other nickeliferous areas have been found in the better known part of pre-Cambrian. The associated metals and the related intrusive rock are generally similar to those at Sudbury, though none of the newer areas can compare with Sudbury area in extent of ore. From a mine in one of them the Mond Nickel Company purchased about 50,000 tons of ore of good grade, and a considerable reserve remains. There is a very good possibility of future discovery of one or more nickeliferous areas in the pre-Cambrian, rivalling in importance the Sudbury district.

X. The Cobalt Silver Area.

North-east of Sudbury, about 80 or 85 miles, is the town of Cobalt, the chief centre of the now famous silver area, which, since its first discovery nearly twenty years ago, has produced a daily average of two short tons of silver for every working day, and during its maximum year reached very nearly 3½ tons per working day.

Dr. Miller, Provincial Geologist, soon found that the silver here is associated with an intrusive sill of diabase generally about 1,200 feet in thickness. The native silver and other valuable minerals are found in a network of cracks extending upward or downward from the sill, and sometimes in the diabase itself; but they generally fade out within a few hundred feet of the intrusive. Valuable quantities of cobalt and arsenic are recovered with the lower grade ores. Much of the ore is extremely rich, yielding many thousands of ounces of silver per ton. Many specimens of nearly pure silver have been obtained, varying in weight from a few hundred pounds to more than a ton.

Cobalt camp is by no means exhausted. Some reserves remain above the sill, though most of the silver produced to date has come from areas whence the sill has been eroded away. Recently the venture is being taken of sinking shafts through the sill and exploring the lower contact, with promising results. There is also a near-lying territory of considerable area, penetrated by the sill, known as "The Gillies' Timber Limit," which will probably produce silver in the near future.

South-east of Cobalt, about 15 miles, there is a second very rich occurrence of silver, similarly associated with a diabase sill, possibly a continuation of the sill at Cobalt, some of the intervening part having been eroded away. The first discovery of silver in this camp, in the township of South Lorrain, was made only a few years later than that at Cobalt, and a few million ounces were soon recovered. Recently after a considerable interval of little or no production, the camp has become extremely active, as a result of the discovery of the famous Wood's Vein or Fault, and of richly mineralised parallel and cross veins near or connected with it, the Wood's Vein, in particular, rivalling or surpassing in richness the most remarkable discoveries at Cobalt. There are important differences between the silver occurrences in this area and those at Cobalt, and now that these differences are coming to be better understood, South Lorrain promises to be of great importance.

North-west of Cobalt, about 60 miles, is a third silver camp, Gowganda, which produced, up to the end of 1922, practically as much silver as South Lorrain, and which has been making quiet but steady progress. Here again, silver is associated with a diabase intrusion, and I may add that one of our most experienced geologists, familiar with the conditions at all three camps, thinks very highly of this camp.

There have been discovered numerous other minor occurrences of silver within this general area, one, the Casey Cobalt, being about 15 miles north-east of the town of Cobalt. Many outcrops of intrusive diabase have been mapped in the general area, roughly 70 miles square, stretching north-

westerly from a line joining the south-east corner of the Sudbury norite laccolith and the southern edge of the South Lorrain diabase sill. The Sudbury norite is probably a differentiation product from the same magmatic source as the diabase, both having been intruded in the Keweenawan epoch. Near Wahnapitae Lake, and generally along the south-west part of the area mentioned, discoveries have been made in which the gold values are more important than the silver. This large area of roughly 5,000 square miles, which, for convenience, I shall refer to as the Cobalt Area, is of great interest for future prospecting. The three chief silver camps in it, Cobalt, Gowganda and South Lorrain, have already produced (to the end of 1923) nearly 350 million ounces (12,000 short tons) of silver. Production in this area is certain of a long future.

About 400 miles in a westerly direction from Cobalt, not far from Fort William and Port Arthur, near Thunder Cape in Lake Superior, is Silver Islet. It is truly an islet, being so small and storm-swept that the Silver Islet Mine, which, after producing a few million ounces of silver, was closed down in 1884, was operated only with considerable difficulty. It is noteworthy as well as suggestive that this silver occurrence was related to a diabase sill somewhat similar to that at Cobalt. The copper ore of Michigan, mined in the Keweenaw Peninsula on the opposite side of Lake Superior, is also argentiferous. The lavas and intrusives of the Keweenawan epoch apparently were the origin of silver mineralisation over a very extended area in this part of the pre-Cambrian. Whether argentiferous formations once covered the great interval between Silver Islet and Cobalt, and have been eroded away in whole or in great part, is at least an interesting speculation, and one on which the geologist and the prospector may cast light in future.

XI. The Porcupine Gold Area.

Lying north and north-east of this large Cobalt Area, and practically continuous with it, is a tract 50 miles wide and 200 miles long, stretching 100 miles into each province from the interprovincial boundary between Ontario and Quebec, which will almost certainly eclipse in total value of production, though not in spectacular discoveries, the famous Cobalt area. This for convenience we shall refer to as the Porcupine Area, since, because of the great gold mines of the Porcupine Camp, this name has come to be very widely known. In many townships in the Ontario part of this tract of country, claims have been staked, and in some instances whole townships have been staked practically solid. Now that attention is turned to the Quebec side of the boundary a similar rush is being made into that province. There are literally thousands of mining claims in the area, on many scores of which valid discoveries have been made, yielding in many cases substantial assays in gold. As a great part of the area is silt-or drift-covered, the difficulty and cost of testing and selecting a claim or group of claims containing a workable deposit of gold are greatly increased. But the areas in the Cobalt, Porcupine and other known promising parts of the pre-Cambrian are large enough, and are sufficiently widely mineralised, to reduce the element of chance to a low ratio, and to make success a reasonable certainty, provided that the work of intensive prospecting is placed under absolutely honest, highly energetic, and thoroughly skilled and experienced technical direction, and provided further that this work of intensive search is widely, courageously and persistently carried on. Future discoveries in areas such as this will result from courage, energy and intelligence, rather than from luck. Porcupine is not a poor man's area, but it is pre-eminently one for enterprising men or groups of men with large means, who can afford a few losses while awaiting success, and who will best be served if they arrange that those whose intelligence and energy win the success are allowed reasonably to share in it.

It was in 1908, four years after the discovery of silver at Cobalt, that the earliest gold find in this Porcupine Area was made, though the first important discovery in Porcupine Camp proper, the outcrop of what is now the Dome Mine, occurred in the following year. Production began in 1911. In spite of the devastating fire of that year and the difficulties of operation resulting from the great war, which have caused a heavy shrinkage in gold production in every other part of the world, the output of gold has steadily increased in this area. The value of the gold production in the Porcupine Area, in the 12 or 13 years of gold mining prior to 1924, exceeded 125 million dollars. One mine, the Hollinger produced a daily average of more than 1,600 ounces during 1922, and has stood

third in the list of the world's greatest gold producers for two years. It is expected that its production will be practically doubled as soon as its new hydro-electric plant, now in course of construction, is completed. This mine has already produced gold worth more than 70 million dollars and has a rapidly increasing reserve of ore, containing at the end of 1923 about 80 per cent. as much more gold. It is said to produce gold at the rate of 150,000 dollars per vertical foot.

The mines so far developed in this area are showing every indication of persistent mineralisation with depth. Geologists have expressed the opinion that the limiting features as the mines deepen are likely to be due to mechanical difficulties, or possibly to increasing rock pressure, rather than to the failure of the ore-bodies. Rise in temperature with increasing depth in the pre-Cambrian is not a serious factor, as shown in the deepest Michigan copper mines, and in one mine of 3,000 feet depth in Sudbury district. The deepest of the mines in operation, now developing ore between 2,000 and 2,500 feet from surface, is the McIntyre, whose ore-bodies have steadily improved in number and size with increasing depth. None of the mines has shown any tendency to become impoverished in gold values as deeper levels are developed.

The principal mines at present in operation in the larger Porcupine area are in two groups located respectively at or near the town of Timmins, the original Porcupine area, and at Kirkland Lake. But the area of actual operation is extending, and there will probably be many more producing mines within the general tract of roughly 10,000 square miles already indicated. Already a dozen mines are producing gold, and it is almost certain that within three or four years this number will reach, and may exceed a score. No one at present can safely hazard a guess as to the ultimate future of the greater Porcupine area, but the probabilities of the area are very great, and its possibilities are literally enormous.

XII. Some Notes on Geology.

Dr. Miller, I believe, regards the auriferous veins as genetically related to the Algoman granite. Dr. Coleman and Dr. Parks, in their text-book on "Elementary Geology," refer to this opinion, apparently with approval. The recognition of the Algoman granite as the origin of the gold in this area seems to be of the greatest importance in the economic interpretation of the pre-Cambrian as a whole. For, to the prospector and the mining engineer, the large areas of granite and gneiss in the pre-Cambrian have, heretofore, been anathema. This discovery is indeed of profound significance, and may revolutionise economic views of large areas of the pre-Cambrian. Up to the present there are very few localities where the Laurentian and the Algoman granites have been separated. It must, indeed, be extremely difficult in most cases to separate them. Yet, if the gold in the Porcupine area is derived from the Algoman granite, and is associated with derivatives (residual quartz veins, dikes, etc.) from this granite, the importance of this discovery and of making the separation between the two granites as rapidly as possible, can hardly be overestimated.

We may at this point profitably digress long enough to catch a glimpse of this later geological view, which, as we have seen, is of much significance in our present discussion. To summarise, my understanding of this view in as few words as possible, the outstanding geological events of the pre-Cambrian may be sketched as follows: Just as an invasion of granites and gneisses on a vast scale, extending over a great period of time known as the Laurentian epoch, gradually lifted and distorted the sedimentaries and lavas of the preceding Grenville and Keewatin series, forming stupendous mountains; and just as the Laurentian epoch of mountain building was followed by another enormous period of time, during which these mountains were eroded to base level and gradually sank beneath the sea, so as to receive the offshore sedimentary deposits of the succeeding epoch; so were the sedimentaries of this succeeding Sudburian or Timiskamian series tilted, folded, and elevated in their turn by a new invasion of granites and gneisses, during a second great period of mountain building known as the Algoman epoch; and so also was this second or Algoman epoch of mountain building succeeded by another vast interval of time, the longest break in Canadian pre-Cambrian geological history, during which the Algoman mountains were also in their turn eroded away to a new base level or peneplain, which received, beginning at or near its southern edge, the sediments, including glacial materials, of the Huronian series. To complete the outline of the

epochs of the pre-Cambrian, we may add that the Huronian epoch was followed by a great sinking of the Canadian Shield beneath the sea, during which the materials of the Animikie series were deposited on the sea-floor; and that this epoch, after a considerable break, was followed by an enormous outpouring of lava, accompanied by many related intrusives—dykes, laccoliths and sills—which furnished most of the materials of the Keweenawan series, during an epoch which in this respect was very similar to the Keewatin epoch at the beginning of pre-Cambrian times. Thus the opening and closing epochs of the pre-Cambrian in Canada were characterised by intense vulcanism with enormous outpourings of lava over large areas of the Shield. The vast amount of time that must have been required for all of these geological changes may easily have been many hundreds of millions of years—may, in fact, greatly exceed in total time the eons that have elapsed between the beginning of the succeeding Cambrian period and the present, comprising the whole of the Palaeozoic, Mesozoic and Cainozoic eras.

Though the geologists of our Dominion and Provincial Departments and of our universities have expressed some of these views, and have adopted some of this terminology, somewhat tentatively, it would scarcely be possible to speak too highly of the way in which they are gradually disentangling the geological history of this vast area, which for a long period appeared to be so hopeless that most of its formations were merely lumped together and cast on one side under the title "basement complex," a label almost of despair. In fact, the term pre-Cambrian itself, which we have used so freely, is a relic of this period of despair, and, I believe, must sooner or later be replaced by one or more terms having a more positive meaning.

To our Canadian geologists must also be given the credit for furnishing a scientific foundation for the work of the prospector, the examiner of mineral claims in detail, and the engineer engaged in the actual work of mining. No one now thinks for a moment of proceeding with these classes of work without the assistance of geological maps. Indeed, much of the work of both general and intensive prospecting is now carried on under the direction and supervision of men who were trained in geology in the universities, and in field-work in the Government geological surveys. As may easily be inferred from the previous discussion, these classes of geological work have a great future before them in the pre-Cambrian of Canada. But this work must not be allowed to interfere with the fundamental scientific work of the geological surveys of the national and provincial Governments, the importance of which can hardly be over-estimated. These departments are not less important as a training school in field geology than for the guidance they furnish to the mining industry.

XIII. Wide Occurrence of Gold in the Southern Pre-Cambrian.

To return from this brief digression on geology: Though gold was discovered in the pre-Cambrian and mined in a small way more than 50 years ago, no marked success in gold mining in this vast area was attained before the first Porcupine discovery. But it is very noteworthy that gold discoveries have been made in most of the series of rocks enumerated, in at least two score localities, widely distributed from the extreme south-eastern limit of the pre-Cambrian in Ontario to the western boundary of the province, and on into Manitoba—a distance of more than 1,000 miles—and at intervals over a wide belt. Since this is nearly all of the pre-Cambrian that has been even run over by prospectors (we can certainly not grant that, except in a few small areas, it has been really prospected), the prospector in any part of the pre-Cambrian would be acting wisely to be always on the look-out for gold. It is more than possible that, with the successful experience in the Porcupine Area back of us, a number of these old and new discoveries beyond the limits of this area may be brought into successful production.

XIV. A Prediction.

Considering all the facts briefly outlined, it would seem possible that the vast pre-Cambrian area may in time become the greatest and most permanent single source of supply of the world's needs in the precious metals. This is not said without due recognition of the great lead in gold production at present to the credit of South Africa. Whatever opinion may be held as to this possibility, it is now practically certain that the pre-Cambrian in Canada will produce vast wealth in gold and silver. The immense possibilities of the pre-

Cambrian in the production of mineral wealth have been, and probably will continue to be, revealed but slowly; partly because of the very great geological complexities referred to; partly because of the costly, though indispensable, work of intensive search for valuable deposits of ore, made necessary by the removal of conspicuous outcrops through glaciation, and by the partial concealment of the surface caused by the widespread mantle of drift left on the retreat of the ice-sheet; partly because of climate, which, though not unendurable, is severe in winter; and partly because, over a large percentage of the area, transportation will be a very difficult problem, the facilities adopted for transportation having few, if any, other supporting industries than mining, though much of the area is within moderate distance of navigable water. But mining men have ever shown remarkable enterprise in overcoming obstacles to transportation, such as would be regarded as insuperable in any other business: witness the transportation improvised to Klondike and to Keno Hill in Yukon Territory, and that now planned to Katanga. A railway in successful operation to Hudson Bay will give access to great areas of the pre-Cambrian.

XV. Iron Ore in the Canadian Pre-Cambrian.

Let us next consider briefly the iron ore resources of the Canadian Shield. We have already glanced at the great iron ore reserves in the Lake Superior region of the United States, and have noted the enormous industrial development in the area lying north of the Ohio River and east of the Mississippi —an unparalleled economic expansion, the key to which is to be found in the deposits of iron ore in that relatively small corner of the pre-Cambrian. We have noted, too, that, though the reserves of ore of suitable grade for direct smelting are still very large, the rate of consumption is also very great—so great in fact that, assuming normal rate of increase, the blast furnaces dependent on them will probably begin to feel the pinch within 25 years; but that already the technical problem of improving the lower grade ores is being vigorously attacked on a large scale.

Now, these iron formations south and west of Lake Superior extend into Canada both at the west end of the lake and across it. Geologists of the United States Geological Survey, familiar with the deposits similar to these on their side of the boundary, on the basis of such evidence as was available, estimated the iron ore in Canada tributary to Lake Superior at 9,000 million tons, having an iron content of 35 per cent. or higher. This did not include the large reserves of ore known at Moose Mountain and in Michipicoten District. Further extensive discoveries of iron ore have been made since this rough estimate was given out, and iron ore of similar grade is known to exist at many other points in the pre-Cambrian, some of these being on islands and on the mainland along the eastern coast of Hudson Bay. The iron ore here is reported to occur in the same formations and under similar conditions to the deposits in the famous Lake Superior region in the United States, and it is believed that search with the diamond drill will reveal rich ores suitable for direct smelting, as proved to be true in the pre-Cambrian ores in United States.

It is more than possible, it is, I believe, probable, that extensive exploration of other large Canadian deposits with the diamond drill may yet prove bodies of ore of suitable grade for direct smelting. Iron ore of direct smelting grade was formerly produced for some years at Helen Mine in Michipicoten District, in Ontario. Failing this, at any rate until the richer ores in Minnesota and Michigan are more nearly exhausted, it can hardly be expected that these lower grade ores will compete successfully with those of higher grade in the United States. As a matter of public policy, the present provincial Government of Ontario has under consideration the provision of a bounty to meet the competitive handicap. In considering the mineral resources of the pre-Cambrian, we are, in any case, safe in assuming that of lower grade iron ores, requiring beneficiating, there are practically inexhaustible reserves; also, that there are good possibilities that supplies of better grade ores may yet be found as prospecting and further exploration of the bodies of ore already discovered are continued.

XVI. Non-metallic Minerals in the Pre-Cambrian.

It would be interesting, if we had the time, to discuss the occurrence of non-metallic economic minerals in the pre-Cambrian. There is a long list of these, some of which occur in great abundance, and seem likely

to become of growing importance as our population increases. Among them are feldspar, graphite, mica, talc, ceramic and other clays, apatite, corundum, magnesite, and molybdenite, as well as building and ornamental stone. The deposits of these humbler minerals will prove to be a very large asset as the pre-Cambrian area becomes more fully developed.

XVII. Direct and Inferential Evidence Regarding the Remote Parts of the Pre-Cambrian.

We have now sketched in broad outline the more important actual achievements in mineral discovery and production in the pre-Cambrian Shield of North America, nearly the whole of which is in Canada. We have noted, as we proceeded, a number of very significant geological facts, having important bearings on various mineral occurrences. We are nearing the point at which reason must be applied to the facts presented, in order to estimate their wider significance.

Before doing so, however, there are two other lines of evidence, which, though not as complete as we could wish, must nevertheless be adduced and carefully weighed in our effort to interpret the pre-Cambrian as a whole. These lines of evidence may be elicited by seeking answers to the two inquiries: (1) What evidence, if any, have we that the remainder of the pre-Cambrian is composed of geological formations similar to those in the area with which we are most familar? and (2) What evidence is there that these outlying parts are similarly mineralised?

(1) The Geological Formations.—The great northern, north-eastern and north-western parts of the pre-Cambrian are geologically but little known. They have been remote and difficult of access; and the seasons suitable for field work are comparatively short. The aeroplane will be of assistance in future study of some parts of these remote areas. A vast amount of geological work remains to be done even in the southern area, which is easily accessible from the Great Lakes, the St. Lawrence River, and the existing railways. The great complexity of the geological problems, which sometimes prove very baffling, has already been commented on. The few geological explorers who have penetrated to these remoter regions, because of these conditions have as a rule been compelled to stick closely to canoe routes. This has generally reduced their reports to accounts of observations along widely separated routes of exploration, under such limitations that only very tentative conclusions as to age relationships of observed rock formations could be reached.

Because of general preponderance of granites and gneisses, which until quite recently were wholly undifferentiated as to age, and are still lumped together as Laurentian (just as most of the pre-Cambrian was formerly labelled "basement complex") vast areas between these routes of exploration are shown on the maps in the same colour as the Laurentian proper. Hence, other formations, shown distinctively on the maps, may generally be considered as having actually been observed; whereas much of the area shown in the conventional colour as Laurentian is, as indicated by the map legends, the significance of which is frequently not fully appreciated, "Laurentian and Undivided pre-Cambrian." The total of the larger areas lying between the travelled routes of explorers, some of them being great blocks of more than 50,000 square miles, which have never been observed even hurriedly by any geologist, amounts to a very large part, probably much more than half, of the entire pre-Cambrian. It is very noteworthy that, as the work of geological mapping proceeds, the apparent Laurentian formation shrinks in area, and the total of the other pre-Cambrian series, which, in general, have so far proved to be more richly mineralised, grows in relative area. Examination of the latest geological maps of Canada shows, in all three of these remoter regions, several large areas of Keweenawan, Animikie, and other series, already noted by the exploring geologists, frequently under local names, the correlation still being doubtful, with wide areas as stated, shown as "Laurentian and Undivided pre-Cambrian," beyond the routes travelled. Even in the Arctic Islands, with a surface exceeding 500,000 square miles, of which the exposed pre-Cambrian may occupy as much as half, though insufficient geological work has been done to determine the succession of the pre-Cambrian formations, geological exploration has yet been sufficient to reveal a great variety of formations similar to those found in Ontario and Southern Quebec. At the recent meeting of the Canadian Institute of Mining and Metallurgy, Dr. Miller, an eminent authority

on pre-Cambrian geology, stated that undoubted Laurentian granite in place is hard to find.

It is, therefore, a natural—and, I think you will agree, warrantable—inference that, as exploring and geological mapping continue, the more highly mineralised pre-Cambrian series noted previously in this discussion will be found, if we compare wide areas and broad averages, in roughly similar proportions to those mapped in the better known parts of Quebec, Ontario and Manitoba. This better known area is the southern part of the pre-Cambrian, to which the St. Lawrence River, the Great Lakes, and the transcontinental railways afford reasonably easy access. It comprises rather less than one-eighth of the entire Canadian Shield, or, roughly, 225,000 square miles. But even of this small fraction of the pre-Cambrian very little has been geologically mapped in any detail, except at and near important discoveries.

(2) The Mineralisation.—The answer to the second inquiry is even more difficult to obtain, and to weigh properly, than the answer to the first; since, obviously, valuable minerals are not as easily discovered as large areas of differing rock formations, in fact are almost never discovered even in detailed geological examination, much less in rapid exploratory work; and since, equally obviously, no serious prospecting on any extended scale, and no serious development of mineral deposits, have been carried out in these at present remote regions, or are likely to be for many years to come. This delay in developing the remoter areas of the pre-Cambrian is all the more probable, because of the great mineral riches, both proven and indicated, which we have noted in the areas more easily accessible at present.

Nevertheless, from the standpoint of wider public policy, it becomes important to use our best judgment and reasoning powers in an effort to forecast the economic future of these great areas as accurately as is at present possible. Canada's present economic unbalance; her widely scattered and sectionalised population; her failure to develop the country beyond the limits of a narrow fringe contiguous to the United States, a fringe that is becoming more and more economically penetrated by the wealthy and enterprising citizens of her consanguineous neighbour; her strong tendency to follow easy lines of imitation in place of striking out boldly on lines of independent policy, based on her own peculiar resources; her consequent tendency to become imitative rather than robustly independent, in the development of her national life; in a word, her habit of looking southward rather than northward for economic opportunity; and the lessening of her independence which results from this habit; these are some of the undesirable results attributable in great part to the failure of Canadians to understand the economic significance of more than half their own country, and of their consequent failure to teach their children, both at home and at school, the economic possibilities of the greater part of their own country, rather than those of the United States.

Let us then further pursue the inquiry regarding the mineral resources of the remoter parts of the pre-Cambrian. This must admittedly be based chiefly on inference. There is, however, a certain amount of positive evidence of much inferential significance.

In the Arctic islands there has naturally been none of the close intensive work of the prospector, so necessary to discovery of valuable minerals in the pre-Cambrian, though geological formations occur similar to those which have been most productive in the United States and Southern Canada. The islands are remarkably free from permanent ice caps, considering their high latitude. The rocks are well exposed in summer. Mica is known to occur at several points in the Grenville formations at the south of Baffin Island, and has been actively mined at Lake Harbour. Graphite has also been mined. Specimens of other valuable minerals have been found. These facts, though comparatively unimportant in themselves, are highly significant as indicating the probability that formations in this northern region similar to those farther south will be similarly mineral-bearing. Sudbury, Cobalt and Porcupine fifty years ago had less prospective value than these formations now possess, since Canadians had before that time had but little reason for thinking that any part of the Canadian Shield would produce minerals of any serious value.

In the great Labrador peninsula, which was added to the Province of Quebec a few years ago, geological exploration has made but little progress in the interior. Iron ore has been reported by Dr. Low to occur on islands, as well as on the mainland

along the east coast of Hudson Bay, under similar geological conditions to the occurrences south and west of Lake Superior. The occurrence of other economic minerals near the same coast is also known. Dr. Low also reports the occurrence of iron ore at the west of Ungava Bay. Dr. Coleman, who made a study of the geology of the north-east coast of Labrador in 1915 and 1916, after referring to the fact that no prospecting has been done, and pointing out that rocks resembling the productive series in Ontario and Quebec cover large areas, ends his memoir with these significant statements: "So far as can be seen the conditions are similar to those which have caused the economic deposits of the Grenville, Timiskaming, Huronian, Animikie, and Keweenawan series of Ontario and Quebec; deposits which have made Ontario one of the great mining regions of the world.

"It is evident that the almost unknown interior of Labrador includes not alone barren granite gneisses, as commonly supposed, but probably also equal areas of other pre-Cambrian rocks of much greater economic promise. It is a region that deserves closer study than it has yet received, and its very bareness and lack of vegetation facilitate such an examination, as compared with regions largely hidden under drift or covered with forest."

In the great north-western area of the pre-Cambrian a little more of the fringes is known. The railway which was begun, some years ago, to connect the Prairie Provinces with Hudson Bay made the so called "Pas Mineral District" on the southern fringe in Manitoba more accessible. This increased accessibility was quickly followed by the discovery and diamond drilling of the Flin Flon and Mandy ore-bodies. The former was proven by drilling to have at least 16 million tons of ore above 900 feet depth, and one or more holes proved the continuance of the ore to 1,800 feet depth. The recoverable copper in this ore probably exceeds 500 million pounds. Mandy Mine was found by drilling to contain a smaller body of very rich ore—25,000 tons averaging about 20% copper, and 180,000 tons running 5 to 8% copper and 20 to 30% zinc, both grades of ore averaging about $5 per ton in gold and silver. Discoveries of a considerable number of gold veins were also made in the same general area at Elbow Lake, Herb Lake, and some other points. Several of these, in spite of the severe handicap of lack of transportation, are being developed, and are reported to be of considerable promise.

Northward from this lies a vast area of pre-Cambrian formations, totalling more than 500,000 square miles, about the geology and minerals of which very little is known, if we except slight knowledge of areas near the large marginal glacial lakes, near the shore of Hudson Bay and along a few routes followed by explorers. Along the west coast of Hudson Bay Mr. J. B. Tyrell noted a large area of Huronian formation, in which he found extensive copper mineralisation. But in the extreme north, the region near Coronation Gulf has been more accessible than the interior, both by way of Behring St. and the Arctic Ocean, and by way of Mackenzie River and Great Bear Lake. Here, south-westerly from the Gulf south-easterly along Bathurst Inlet, and easterly from it, as well as on many small islands in these waters, are large areas of Keweenawan lava, similar to the copper-bearing eruptives of Keweenaw Point in Michigan, which, as we have noted, have made that peninsula one of the most productive copper regions known. The Eskimos have for many years satisfied their small requirements for metal by visiting annually Copper Mountain on the Coppermine River, a mountain near Prince Albert Sound on Victoria Island, and some other points, where they picked up small supplies of native copper. Several exploring parties have proven the existence of copper over extensive areas, under similar geological conditions to those in Michigan. It is not possible in this paper, and it would in any case be a digression from our main theme, to review the discussions that have been printed regarding the possible economic value of these deposits within any near future. It is worth noting that coal is known to occur in some of the Arctic Islands, notably on Banks, Melville and Bathurst Islands. Toward the close of the Great War the Federal Government, on the advice of its technical experts, considered the mineral area near Coronation Gulf of sufficient importance to withdraw from staking this area and the territory to the northward.

Now, is it not remarkable as well as highly significant, that, again, where reasonable access has made examination possible, the formations have been observed to be similar, and similarly mineralised, to those found

near the extreme southern rim of the pre-Cambrian? Those who know the pre-Cambrian best, from long first-hand experience in it, may feel that this question would have more point if reversed, thus: Would it not be even more remarkable had examination shown that this region differs from the better known parts of similar formation in the pre-Cambrian, in not being similarly mineralised? In any case this occurrence, at a distance of 1,500 miles from that in Keweenaw Peninsula, Michigan, must add greatly to the sense of uniformity in the pre-Cambrian for those not thus experienced. A clear conception of the immense scale on which the major events occurred in pre-Cambrian geological history will add greatly to the attentive student's growing sense of broad uniformity over the whole of this immense area. But the caution, of regarding only broad averages in interpretation, must be repeated.

XVII. General Conclusion regarding Mineral Wealth of the Pre-Cambrian.

Now, let us stand off far enough to view broadly, and to see in proper mental perspective, the great facts and principles we have considered, so as to grasp clearly their wider significance. To summarise: We have made an effort to comprehend the vastness of the pre-Cambrian Shield in Canada, with its area of 2,000,000 square miles, occupying well over one-half the surface of the country. We have noted briefly the enormously long geological history revealed by its rock formations, probably extending to greater length than all subsequent geological time. We have glanced at its vast epochs of mountain-building, each followed by a great period of geological degradation and later sedimentation. We have seen that these immense geological cycles were on so great a scale that the Shield, though of such extended area, was practically a unit in relation to the profound effects of the long continued action of these geological agencies and forces. We have observed, finally, that nearly all traces of geological history throughout Palaeozoic, Mesozoic, and Cainozoic time over this great area have been swept away; that only a few tens of thousands of years have elapsed since there retreated from almost the entire area an enormous glacial ice-sheet, which had covered nearly the whole northern half of the continent for a very long stretch of time, with some inter-glacial periods, each of which is thought by Dr. Coleman to be of greater length than the entire period since the final retreat; and that during this glacial period the accumulated residual débris of ages of ordinary erosion was swept away, the present topography of the area was completed, and the pre-Cambrian formations were left exposed, except for a relatively slight mantle of drift over parts of the area, making possible a study in detail of geological history and structure, and discovery of mineral resources, over an area equalled nowhere else.

We also briefly reviewed the achievements in mining and in proving reserves of mineral wealth in the southern fringe of the pre-Cambrian, in the Lake Superior Iron Mines, the Michigan Copper Mines, the Sudbury Nickel-Copper Mines, the Cobalt Area Silver Mines, and the Porcupine Area Gold Mines, and noted the great future probabilities in each instance. We might further summarise the achievements in mining by saying that these five great areas have already produced mineral wealth which, in its crude forms of iron or steel, copper, nickel, gold and silver, as these metals left the hands of the metallurgists, had a gross value of not far from 15 billions of dollars. But even more important is the fact that these mineral products became generally the raw materials of a great number of manufacturing plants from which they issued with a value of some scores of billions of dollars. They thus became the material foundation of a large part of the capital wealth, and of the civilised life of much of the continent of North America, illustrating incidentally the truth of the generalisation that mining is the basic industry of civilised progress on its material side, as agriculture is of subsistence. We might add that the known mineral wealth remaining in these five important areas is certainly several, and probably many, times the mineral wealth already produced.

We next noted that, in addition to the probability of broad uniformity of general geological formations, as would be suspected by inference, this broad uniformity over the Shield is reasonably confirmed by observation, as far as geological exploration has extended. We noted, too, that the inferential suspicion that similar mineralisation would broadly follow similar geological conditions because of the wide geological uniformity proven to exist, is confirmed to as great an extent as could at present be

expected, in view of the entire lack of intensive prospecting in the remoter regions —a method of search that has been found indispensable in the regions best known.

Are we not, then, justified in taking the next inferential step? Canadians have centuries of geological work and detailed prospecting ahead in the pre-Cambrian. Are these arduous and costly classes of work of sufficient promise to warrant their being energetically, persistently and widely carried on? Over an area so vast, and broadly so uniform, in rock formations and mineralisation, is it not a reasonable certainty that the achievements of the past, both in discovery and in recovery of minerals in but a few per cent. of the total area will be repeated over and over again in the great pre-Cambrian area as a whole? It would naturally be folly to predict how many times the value of the mineral wealth already discovered and recovered will be repeated. But that it will be repeated again and again no man who grasps the facts and who trusts his reason will deny.

During the first few years of my engagement in mining in the pre-Cambrian area I had serious doubts as to its mineral possibilities. Gradually the greatness of its mineral wealth became a probability. I have now had twenty years' experience in the area, during which period I have tried, by as wide observation and study as possible, to comprehend the economic significance of the pre-Cambrian, and have become fully convinced of the truth of the inference stated regarding its vast mineral wealth.

DISCUSSION.

THE CHAIRMAN (Sir Richard Redmayne) said they owed a debt of gratitude to Dr. Corless for the very admirable address which he had delivered. He (the Chairman) would have liked a week or two in which to study the paper thoroughly before commenting on it. It was bristling with matter of interest. It appealed not only to the practical man, the prospector, the geologist, the man of business, but to the pure scientific geologist also. As to the lecturer's explanation of the outstanding geological events of the pre-Cambrian, he had marked half a column of that portion of the paper, which was most fascinating and most interesting reading; but when the lecturer came to the conclusion of the explanation of the pre-Cambrian formation, he was left gasping, like a fish that had recently been pulled out of water, for Dr. Corless required, not a million or a few millions of years, but millions and millions of years for the carrying out of the geological processes which had left the pre-Cambrian in the state it now was. He had not the slightest doubt that Dr. Corless was right, but he (Sir Richard Redmayne) would like, some time, to debate that question. What appealed to practical people was this point: what evidence was there that these outlying parts were similarly mineralised? That was a matter of the very highest importance, and the reasons that Dr. Corless had given for his belief that they were, were of very far-reaching interest. The pre-Cambrian (which in his youth he was taught to call the Laurentian, named after the St. Lawrence River) in other parts of the world had certainly been very fruitful of great mineral wealth —platinum, silver, gold, cobalt, nickel and plumbago. As to the plumbago of Ceylon and the great banket deposits of South Africa, it was agreed among the most eminent geologists that these as well as the goldfields of Western Australia were of pre-Cambrian origin. The greatest source of gold at the present time was formed by the banket deposits of the Rand. Looking to the future, he thought there was little doubt from the indications which were forthcoming, and from what Dr. Corless had said, that the centre of gravity, so far as the gold production of the world was concerned, would shift, not slowly but rapidly, to Canada. Anybody who had given time to the study of the Porcupine deposits must come to the conclusion that their possibilities were immense. Before he sat down he would like to try and point the moral. In Canada they had all this enormous mineral wealth; but what were they, in Great Britain, doing to assist in its development? The United States of America was doing a very great deal, but surely Britain ought to have a hand in it. He believed it was a fact that only some 2.8 per cent. of the capital invested in gold mining in Canada was purely British. That did not seem right. He hoped and believed that Dr. Corless's paper would be read broadcast. He was glad Dr. Corless had chosen the Royal Society of Arts for his starting-off ground, because in that way the paper would receive very wide circulation and very wide consideration by the best possible type of mind. There was one thing he would ask. Towards the end of the paper, Dr. Corless had said: "It is worth noting that coal is known to occur in some of the Arctic Islands, notably on Banks, Melville and Bathurst Islands." He did not suppose Dr. Corless meant by that that it occurred in the pre-Cambrian.

DR. CORLESS: No.

THE CHAIRMAN said he thought not, but he wanted to be sure of that, because otherwise it would upset the whole of his ideas as to the formation of coal.

SIR THOMAS HOLLAND, K.C.S.I., K.C.I.E., LL.D., F.R.S., said he would make his remarks as brief as possible for two excellent reasons. One was that there were so many distinguished Canadians present that one wondered how the business of the Dominion was being carried on during that month!

The other, and more important one for him, was that he was shortly going to visit Canada, and the remarks he would make that afternoon were bound to be tinged with the out-of-date impression left upon him after his last visit, in 1913. The less he said that day the less he would have to answer for when he got across to Toronto next month. There was one feature of Dr. Corless's paper which struck him as being of extreme interest, and that was where he referred to the discrimination between the Algoman series of granites and the old Laurentian granites. In the old days they used to look upon all the great granitic or gneissose series in the Archaean part of the pre-Cambrian as being roughly of about the same type. They varied locally, and they gave a certain amount of amusement to the microscopic petrologist, but generally they were treated as of the same great family. So long as that idea existed prospecting through these Archaean areas was a matter of chance, and a very small chance, too. A needle was a very prominent article in a haystack compared with gold deposits on the enormous stretches of Archaean which existed on the world's surface. The Canadian geologists had gone a very big step forward in showing them that there was a fundamental difference between the old Laurentian granites and those which they had distinguished as Algomans. He would not say the Algoman granite brought the gold in, but the intrusion of the Algoman granite gave rise to that form of rejuvenation of the old Archaean lines which resulted in the concentration of gold deposits like that of the Porcupine and similar areas. In the same way they had connected the diabase intrusions of Keweenawan age with the silver deposits of Cobalt and the nickel-copper ores of Sudbury. These particular forms of discrimination had enabled prospectors to confine their operations to certain areas, and, secondly, to look hopefully and intelligently at those areas where there were geological features of the kind indicated as promising. Still, there was room for further discrimination in a narrower circle. It was all very fine to say that the great areas of pre-Cambrian Canada gave such brilliant results as Porcupine, Cobalt, and Sudbury. But there were still enormous areas that were pre-Cambrian, and even areas that contained Algoman granites which were not Porcupines, not Sudburys and not Cobalts. It was just there that the precise discrimination by the geologist became necessary. A great deal of harm was done in the old days by the assumption that the great Archaean areas must necessarily be barren because most of the ground covered and accessible was found to be barren. A good deal of harm was done after the discovery of some promising places in jumping to the conclusion that they were going to have any number of South Africas and any number of Porcupines in other parts of the pre-Cambrian shield in Canada. That harm would not be permanent so long as the facts dealt with were sifted by men who, like Dr. Mackintosh Bell, Dr. Corless, Dr. Miller, Dr. Brock, and others he might mention, had superseded the old rule of thumb of prospecting work in Canada, and turned it into real science, showing that the discrimination they made was not a crude discrimination, but one which enabled them to say definitely they did not assume that because they had Algoman granites they were going to have Porcupines. One had only to take the case of the Keeley mine as an instance of remarkable discrimination. The old Keeley mine, which broke one of the big banks of Toronto, and was the cause of getting the manager into trouble because of his confidence in it, was taken over for a small sum of £20,000. After the work of Dr. Mackintosh Bell, who merely set the operations going a short distance away from the place where they had been worked before, the Keeley mine had since produced enormous quantities of silver. The great value of the work which had been done by Canadian geologists was in discriminating between pre-Cambrian that was of no use and pre-Cambrian that was hopeful, and between pre-Cambrian that was hopeful and pre-Cambrian that was valuable. Nothing was more admirable than the discrimination and care which the Canadian geologists had shown in examining the residue which was hopeful. He was perfectly sure that the impression that had been left in England, alternately too hopeful and too depressing, would be removed in a very healthy way by papers of the kind that Dr. Corless had read. Possibly, after the members of the Society, numbering 3,500, had read the paper they would begin to forget what they did with the money which they put into Grand Trunk debentures.

Dr. W. G. Miller, F.R.S.C., F.G.S. (Canada), said that Dr. Corless had been doing considerable missionary work in Canada in connexion with the pre-Cambrian. The ordinary man in the street had not heard much about it until Dr. Corless began to give some addresses on the subject a few years ago. The population was getting greatly stirred up. A short time before he left Toronto a representative of a Board of Trade came to see him, stating that he had been importuned to get out a pamphlet on the pre-Cambrian, and he wanted to find out what it was. Apparently, he did not know whether it was an animal or a vegetable! They had had very many discussions on the pre-Cambrian in Canada, but it had never been discussed under the conditions under which they were discussing it then. One never had a Gainsborough or a Reynolds looking down on him during the discussion of the subject. There were two or three points in Dr. Corless's paper which he would like to refer to briefly. Dr. Corless made an interesting reference to certain historical occurrences, and he had often thought what would have happened in connexion with the political status of North America if the Cobalt silver area had been discovered during the French period. That area had produced roughly 350,000,000 ounces of silver, which would have been worth in those days nominally £100,000,000; £100,000,000 in those days would be worth about one billion

pounds in these times. Those fields could have been worked just as easily in the French period as they were worked to-day, because they were near the great Ottawa River. The French could have taken out much of that silver. If that area had been discovered in those days what would have happened ? The French probably would have come over in such great numbers that they would have held Canada. If they had not succeeded in holding it the colonists would have taken it over, and then, when the Revolution of 1776 came along, it would have become part of the United States of America. Discoveries were made along the Ottawa River long before, in the 17th century. One of the oldest known ore deposits in North America was in the Lake Timiskaming extension of the Ottawa River, nine miles from Cobalt. The early explorers went up in birch bark canoes. That was, no doubt, the earliest thing the explorers found. The Cobalt area escaped till a more opportune time, and the whole of the pre-Cambrian had been held up. However, they had so many debts to pay that it was just as well that development had been delayed, and in that sense, perhaps, there was the hand of Providence in it.

Dr. D. B. Dowling (Canada) thought he might give his conception of the history of the pre-Cambrian in this way. Since he had been in London he had seen objects of art, architecture, and other things which carried the mind back in time to very remote ages. Part of those things were dated definitely. There were pictures painted in a certain year; there were houses built in a certain year. One went to the British Museum and saw certain things which were older, and then one lost the scheme of dates. Such a thing was "about the 3rd century," or "about the 10th century," or "between the 11th and 12th century," etc.; so in modern history they had a different set of scales. For recent times the scale was definite, but, as they went back, the scale became a little more indefinite, and one had then to adopt a new method of adjustment to see how old the thing was. Exactly the same thing happened in geological history. One could say almost definitely the age of certain rocks by the history of the neoliths found in those rocks; but then they came to a series of rocks in which the method of estimating time was by a different scale. Could they not compare these two things ? Modern history was very definite—back to the Christian era, to the first century. Beyond that one could go back till one ended with Adam, but it was not definite. It was the same thing in the pre-Cambrian. They came to the time when they could historically estimate the lapse of time in regard to the rocks. When they went back to the time of the first crust of the earth, listening to Dr. Corless and the other geologists who were working on that area, they found there was probably not any one original crust of the earth; in other words, the earth in that very remote period passed through several stages. There were crusts at different times, and it was in those crusts that these metalliferous deposits had been deposited. The next important subject of study in their old history was to trace the different ages and to find in the rocks the different minerals which belonged to each, because he had some idea that the older ones had different metals from the newer ones.

Dr. J. W. Evans, C.B.E., F.R.S., said that the one thing which had struck him with regard to the valuable mineral deposits in the pre-Cambrian of Canada was the accidental way in which they were originally discovered. The copper deposits of Sudbury, which afterwards became very valuable for their nickel, were discovered in the course of making the Canadian Pacific Railway. The silver, cobalt, and nickel deposits at Cobalt were found in the same way. The glacier ice sheet had done a great deal in clearing away the decomposition products from the surface of the earth, but it had not entirely done it. As a general rule, one must not expect to find valuable minerals in the whalebacks or whale-shaped masses of rocks which were so characteristic of that country. As one travelled through the country one saw these great surfaces of rocks and one might think that prospecting for minerals would therefore be very easy; but one must remember the glaciers, as they passed across the country, had carried away the soft material, and these whalebacks represented the hard barren material where one could not expect to find anything. But when they came to make a railway, which followed the low ground where there had been erosion, they found mineral deposits which could never have been discovered by examining whalebacks. The possibilities arising from this great mass of pre-Cambrian rocks were far vaster than had been supposed. They were covered and hidden, if not by decomposition products, by vegetation. The problem was how to come upon the ancient sulphide deposits under the surface of vegetation. It seemed possible that the newly developed method of electrical prospecting might solve the problem. By a system of drawing equi-potential lines across the country they were able to find any rocks down to a depth of several hundred feet the conductivity of which was greater than that elsewhere. By this means the Swedes had been able to locate pyritic deposits in Sweden, and the same method was being applied in Spain. The question was whether that method might not be applied, with certain modifications suggested by experience of the country, to the great pre-Cambrian of Canada. In many cases these pre-Cambrian rocks were covered over by early Palæozoic sedimentaries. It was probable that under these sediments, which might not be of extreme depth, there were riches quite as great as those exposed near the surface. Was not it possible that by this system of electrical prospecting, or by other means, that science might develop in the future, one might find that hidden mineral wealth ? He had been very interested in listening to Dr. Corless's lecture, and he thought, if it were widely read, it would make people realise

the extraordinary possibilities of the great Dominion of Canada.

Dr. R. W. Brock, F.G.S. (Canada), said he was quite as enthusiastic and as optimistic as Dr. Corless regarding the mineral possibilities of the great pre-Cambrian area, but he thought that possibly the estimates of the agricultural land were a little conservative. Some of the area which was not included in agricultural land would prove to be of agricultural value. That was particularly the case with British Columbia, which was regarded as so mountainous as to be almost totally excluded from the area of agricultural possibilities. With regard to the copper at Coronation Gulf, he could scarcely agree that it was found on account of its accessibility. It so happened that several of the earlier explorers got into difficulties up there, where they became acquainted with the fact that the Eskimos had native copper. It was owing to that fact that definite steps were taken to get information regarding this occurrence of native copper in the Coronation Gulf. Mr. Stefansson was going up there to study the Eskimos and the fauna. He gave Mr. Stefansson some specimens to show the Eskimos so as to get them to tell him where they got them from. Dr. Douglas, who was one of the leading copper men of the United States, though a Canadian by birth, wanted to give a trip to a nephew of his, who desired to do something worth while, into some very difficult country. So he suggested to Dr. Douglas that he should send his nephew up into this Coronation Gulf district. Both Mr. Stefansson and Dr. Douglas's nephew got many specimens showing native copper. They brought back about 75 specimens of the typical copper-bearing formation of the pre-Cambrian, and native copper occurred in 72. That was obtained from various points in the neighbourhood of the Coronation Gulf. Dr. Douglas was so impressed with its possibilities that he was quite prepared himself to undertake the prospecting and development of that country, if he could have made suitable arrangements.

Mr. William L. Griffith said that all those associated with Canada must have been greatly cheered by what had taken place that afternoon. They had had a distinguished scientist from Canada, a man of great integrity of character, whose words carried weight wherever he was known, reading a paper which had borne out so much of what Canadians hoped for, and the statements in that paper had been supported by such a great authority as Sir Richard Redmayne. Then his friend and colleague, Dr. Miller, departing from the safe ground of geology, had gone into higher altitudes and had told them that all this great wealth had been reserved by a wise providence on behalf of British subjects. He did not know that they could desire anything more than that. The Royal Society of Arts was greatly to be felicitated upon the success of the meeting. If he made a few observations somewhat personal to the Chairman, he hoped Sir Richard Redmayne would forgive him; but some years ago Dr. Miller came over to this country on behalf of the Dominion Government to conduct certain negotiations, and he called upon him asking: "Do you know Sir Richard Redmayne?" He said: "No, I do not, but I hear he is clever and energetic, and you will have to watch him, because these English officials have a way, when they want to build up an organisation, of putting the English in the middle and the Dominion representatives as satellites revolving round. I think, therefore, you had better watch him." He saw Dr. Miller some time after that and said: "Well, what about Sir Richard Redmayne?" and Dr. Miller said: "He is a splendid fellow. He seems very reasonable, and I think we shall get along with him." Ultimately, he (the speaker) came to know Sir Richard Redmayne, and to know him was to trust him. However dense the domestic official fogs were in his office, when Sir Richard Redmayne called his genial presence dispelled them, and he had found that his own connexion with him justified Dr. Miller's description fully. They heard a good deal about constitutional difficulties within the Empire which were going to create all sorts of troubles, and which were going to break the Empire to pieces; but his view was that, if they had administrators of the capacity and geniality of Sir Richard Redmayne, all these difficulties would pass away. Tact in administration was the great thing. It did not matter what the law was or even what the Constitution was so long as they had men like Sir Richard Redmayne to carry on negotiations between the Englishman and the, perhaps, somewhat susceptible Dominion representative. He had great pleasure in expressing their thanks and appreciation for the thoroughly useful and cheerful prospect presented by Dr. Corless in his paper. They were living at a time of impending financial doom; but perhaps Lord Durham was right when he said he called upon the young land of Canada to redress the balance of the old world.

Dr. Henry M. Ami, F.G.S. (Canada), said he had great pleasure in seconding the vote of thanks to Dr. Corless for his magnificent presentation of the mineral wealth of the pre-Cambrian, and to Sir Richard Redmayne for his kindness in presiding. When 2,000,000 square miles were in the balance it it meant a great deal. There was one mineral, however, which had not been referred to, namely, the diamonds; eight of them had been found in the gravel south of the present international boundary line. When would the diamond field of Canada or of the pre-Cambrian be discovered?

Sir Richard, as Chairman-Governor of the Imperial Mineral Resources Bureau, had done good work for the Empire. He was doing it well, and it was hoped that he would long continue to take the active part he had taken in advancing the welfare of the great Empire, to which we belong.

Dr. Corless briefly acknowledged the vote of thanks.

SIR RICHARD REDMAYNE expressed his thanks and gratitude to Mr. Griffith, who had always helped him with his advice and sympathy. He would like to take this opportunity of publicly expressing his thanks to Mr. Griffith for his kindness during the time he was occupying a very important position in the Canadian Office in London, as representing the great Dominion.

LA VIE INDUSTRIELLE EN FRANCE.

L'AUTODROME DE MIRAMAS, PRÈS DE MARSEILLE.

Jusqu'ici la France ne possédait pas d'autodrome, et les courses et concours d'automobiles, qui ont un succès de plus en plus grand, devaient être organisés sur des circuits improvisés empruntant les routes. Cette solution présente des difficultés et des dangers, aussi a-t-on décidé la construction de deux autodromes : l'un à Montlhéry, à une vingtaine de kilomètres de Paris, est en construction, et l'autre, à Miramas, près de Marseille, a été inauguré le 13 Juillet.

L'autodrome de Miramas est un des plus grands existant jusqu'ici. Sa piste a, en effet, une longueur totale de 5,000 mètres (5,470 yards), tandis que celui de Brooklands n'a que 4,630 yards et celui d'Indianapolis (U.S.) 4,410 yards. La piste de Miramas se compose de deux lignes droites réunies par des arcs de cercle de 150° ; entre les droites et les arcs se trouvent des raccordements paraboliques. L'ensemble occupe une longueur de près de 2,000 mètres (2,187 yards) et une largeur de 960 mètres (1,050 yards).

La piste a une largeur de 16 mètres (52ft. ½), avec une pente transversale de 2.75% dans les parties en alignement droit et de 5% environ dans les parties circulaires. La piste est prolongée vers l'intérieur par une contrepiste en terre de 5 mètres, et vers l'extérieur par une contrepiste en remblai de 4 mètres.

Une petite piste triangulaire a été établie à l'intérieur, à une extrémité, pour permettre d'imposer à volonté aux véhicules, des virages très courts, pour certaines épreuves.

Le terrain se prêtait très bien à l'établissement d'une piste ; il est plat, et à très faible profondeur se trouve un poudingue incompressible. La superstructure est constituée par un revêtement en béton de ciment de 15 centimètres (6 in.) d'épaisseur. Les matériaux pour constituer ce béton ont été excavés a proximité de l'autodrome, sous la couche de poudingue. Le béton a été mis en place suivant la méthode américaine, au moyen d'une machine Lakewood. Cette machine est constituée par un pont roulant automoteur, se déplaçant sur deux rails spéciaux, qui servent en même temps de coffrages latéraux pour le béton. A l'avant se trouve un gabarit de tôle qui répartit le béton ; à la suite est placé un madrier pilonneur ; à l'arrière, enfin, agit une courroie de finissage.

Les tribunes, placées sur un des grands côtés, ont une longueur de 300 mètres, et comportant 12 rangs de gradins en béton armé. La couverture, également en béton armé, présente un porte-à faux de 10 mètres, sans aucun point d'appui intermédiaire.

A l'intérieur de la piste, en face des tribunes, se trouve un pavillon contenant les services des postes et télégraphes pour la presse, avec poste de T.S.F., une salle pour les journalistes, une autre pour les chronomètreurs, et sur la toiture les tableaux d'affichage. Un mur de cloture de 7,500 mètres de longueur totale entoure la piste, en réservant des espâces où pourront se garer les automobiles.

La première course, le 13 Juillet, a montré le bon fonction de l'autodrome et de ses services annexes.

LA SOCIÉTÉ DE RECHERCHE ET DE PERFECTIONNEMENTS INDUSTRIELS.

L'application des recherches scientifiques à des buts industriels est réalisée en France dans plusieurs établissements nationaux, et principalement au Conservatoire des Arts et Métiers, à Paris, et à l'Office National des Recherches scientifiques et industrielles, à Bellevue, près Paris.

Plusieurs savants et industriels ont jugé cependant utile la création d'une organisation privée, indépendante de ces établissements officiels, et ils ont constitué la Société de Recherches et de Perfectionnements Industriels.

Cette société offre aux industriels d'exécuter pour eux les recherches scientifiques dont ils ont besoin pour améliorer leurs fabrications, ou pour trouver des procédés noveaux répondant à des besoins spéciaux. Des conditions établies dans chaque cas fixent la rémunération demandée à l'industriel, et les droits éventuels de la Société aux bénéfices des inventions qu'elle pourra faire breveter.

La Société a déjà réalisé des recherches importantes, et elle en poursuit d'autres. Elle étudie notamment la combustion du charbon pulvérisé, en vue d'améliorer les appareils employés jusqu'ici à cet usage. Elle a mis au point un procédé de purification des charbons cendreux, en partant des méthodes de l'inventeur américain William Trent. Elle a trouvé divers perfectionnements aux procédés de goudronnage des chaussées, d'imprégnation des pavés de bois, de briquetage, etc. Elle a aussi monté une usine d'imprégnation, qui fournit des pavés de bois à la Ville de Paris.

D'autres études sur la putrescibilité des farines, sur les laques, sur le traitement des eaux d'égout, etc., ont été réalisées. Enfin, le service mécanique de la société a imaginé et construit des balances destinées à être suspendues à des grues, ponts-roulants, etc., et dans lesquelles les couteaux sont remplacés par des roulements à billes.

Bien que fondée depuis peu, la Société a déjà résolu d'importantes questions industrielles, et en étudie actuellement un assez grand nombre.

Chacune de ces études est faite à la demande

d'un industriel, et les résultats en sont tenus complètement secrets.

Les Installations Mécaniques et la Protection contre l'Incendie aux Nouveaux Magasins du Printemps, à Paris.

Les Magasins du Printemps occupent, au centre de Paris, deux vastes immeubles entre la Boulevard Haussmann et la rue de Provence, sans compter deux magasins annexes, donnant également sur la rue de Provence. En Septembre, 1921, au moment où l'on s'apprêtait à finir la construction du second de ces immeubles, entrepris dès avant la guerre, un incendie considérable la dévasta en quelques heures. La charpente métallique fut fortement éprouvée et il fallut la démonter entièrement, pour remettre les fers en bon état ou les remplacer, avant de les assembler de nouveau.

Ces travaux de reconstruction, tout importants qu'ils soient ne mériteraient pas une mention particulière, si l'on n'en avait pas profité pour mettre les nouveaux magasins au premier rang des progrès accomplis dans la protection des édifices publics contre l'incendie, et dans l'aménagement des magasins suivant les méthodes les plus modernes.

Les nouveaux Magasins du Printemps couvrent 5,000 mètres carrés (53,820 sq. ft.) et comprennent deux grands halls de 6 étages, couverts par des dômes dont le sommet atteint 40 mètres (131 ft.) de hauteur au-dessus du boulevard. Ces deux halls sont séparés par une cage centrale fire proof, comprenant 12 ascenseurs et 2 escaliers, dont un mécanique, ainsi que par des doubles rideaux (coupe-feu). De même, les cages d'escaliers sont fire proof, et les vitrages sont constitués par de petits carreaux enchâssés dans une monture métallique.

Plus de 6,000 sprinklers sont disséminés dans les plafonds, à tous les étages, et un réseau d'avertisseurs d'incendie, du système "Thermosonus," est également réparti à tous les étages; il permet, de même qu'un réseau téléphonique spécial de sécurité de signaler à un poste central de surveillance toute température anormale dans un endroit quelconque.

Les canalisations d'eau sont multiples, et agencées de façon à faciliter la défense contre le feu. Une centaine de postes d'incendie sont également répartis un peu partout.

Bien entendu, les magasins sont reliés directement au poste des pompiers de la Ville de Paris.

L'éclairage est très important: on n'a pas hésité à porter à 60 bougies par mètre carré l'intensité de l'éclairement des surfaces de vente, au moyen de lampes de 400 bougies, enfermées dans des globes diffuseurs. Avec les lampes décoratives disposées en cordon le long des balcons, etc., on arrive à un total de 18,000 points lumineux, sans parler des illuminations extérieures, pendant les fêtes par exemple.

L'éclairage complet n'exige pas moins de 1,200 kilowatts, et le courant de force (ascenseurs, escalier mécanique, ventilateurs, réseau pneumatique, etc.), exige 600 kilowatts.

La partie la plus nouvelle de l'agencement des magasins, au point de vue de la vente, est la centralisation des opérations de caisse dans deux caisses centrales, reliées aux rayons de vente par un réseau de tubes pneumatiques: on envoie ainsi du rayon à la caisse les papiers concernant les achats, et aussi, en cas de paiement immédiat, l'argent remis par les clients; la caisse renvoie la monnaie au rayon, par le même système.

DEVELOPMENT OF NORTHERN MANCHURIA.

The population of northern Manchuria has increased from 2,000,000 to 12,000,000—equal to the estimated population of Siberia—since the inception of the Chinese Eastern Railway, which operates over 1,100 miles in this district, according to a report by the United States Commercial Attaché at Peking. The greater part of this increase, moreover, has occurred in the past decade. There are about 200,000 Russians.

Agriculture yields 83 per cent. of the total production value of northern Manchuria and constitutes more than 90 per cent. of its exports. The principal agricultural products are timber, soya beans and wheat. Field crops in 1922 aggregated 9,500,000 short tons, 22 per cent. of which consisted of beans and 17 per cent. of wheat. The balance, 61 per cent., was in kaoliang (kaffir corn), millet, maize, and other grains. The 35 modern flour mills in the railway zone consume 10,000,000 bushels of wheat annually. The value of the output of the bean-oil mills in this area is equal to one-half that of the production of the flour mills.

Of the 600,000,000 head of sheep produced in the world, China may claim 45,000,000 head, one-half of which come from Mongolia and Manchuria, with 11,000,000 head in the region contiguous to the Chinese Eastern Railway. This territory produces 3,500,000 head of horses, 5,000,000 head of large-horn cattle, and 3,200,000 pigs.

GENERAL NOTE.

Madagascar Ant Wax.—Considerable activity has taken place recently, writes the United States Consul at Antananarivo, in the gathering and exportation of a product called "lokombitsika," a kind of gum or wax produced principally in the Province of Fort Dauphin, inthe southern part of Madagascar. This material is said to be formed on the branches of trees in the forests by a kind of ant insect known as the "Gascardia Madagascariensis." Its exportation has been confined recently to France, where it is employed in connexion with the manufacture of varnish and possibly for other purposes. It is sometimes sold as gum lac. Previous to the war sample lots of this wax were sent to Germany by the German firms then doing business in Madagascar. The gathering season would appear to be from June to September, and the average quantity now being produced or taken is reported as about 50 to 75 tons per year.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICE.

COMPETITION OF INDUSTRIAL DESIGNS.

On Tuesday, August 12th, the Queen, attended by Lady Bertha Dawkins, honoured the Royal Society of Arts by visiting, the Exhibition of selected works submitted at the Society's Annual Competition of Industrial Designs, which is now being held, by the courtesy of the Director, in the North Court of the Victoria and Albert Museum, and remains open until Saturday, 30th inst. Her Majesty was received by Lord Askwith, K.C.B., K.C., D.C.L., Sir Frank Warner, K.B.E., and Mr. Carmichael Thomas, members of Council. Sir Cecil Harcourt Smith, C.V.O., LL.D., Director of the Victoria and Albert Museum, and Mr. Eric Robert Dalrymple Maclagan, C.B.E., were also present. The Queen evinced great interest in the Exhibition, and graciously expressed her desire to purchase one of the designs.

The following Report on the competiton of Industrial Designs has been issued :—

INTRODUCTION.

One of the chief objects of the Royal Society of Arts was declared by its founder to be "the training of young people for the pursuit of the Industrial Arts." In the very first list of premiums, published in 1754, a set of prizes was offered for boys and girls between fourteen and seventeen for "the most ingenious and best fancied designs, composed of Flowers, Fruit, Foliage and Birds, proper for Weavers, Embroiderers, or Callico Printers"; and a similar set of prizes was offered to children below the age of fourteen, in the hope, it has been said, that their fresh young minds might produce something less hackneyed than the designs then available. For many years similar prizes were offered by the Society; a large number of awards was made; and in 1778 it was claimed that "the elegance of pattern adopted by weavers and callico-printers may with justice be attributed in a great degree to the rewards and attention bestowed upon them by the Society."

In the earlier part of the nineteenth century the Society for various reasons discontinued these awards and turned its attention elsewhere; but in 1876 a small trust fund was handed over to it, to establish a memorial to the well-known architect and ornamental designer, Owen Jones, and since then a number of prizes have been awarded annually to students in Schools of Art. These competitions met with a reasonable amount of success, but it was felt by the Council that a great deal more might well be done to encourage not only the student but also the young practising designer. As a beginning they appointed five strong committees, consisting mainly of manufacturers, to deal with Architectural Decoration, Textiles, Furniture, Book Production, and Pottery and Glass, with a Central Committee under the chairmanship of Sir Frank Warner, K.B.E. These committees were unanimously of opinion that the best means of bringing to light young designers of promise was to hold an annual competition open to two classes of competitors—(*a*) students in British Schools of Art, and (*b*) all British subjects. In order to add to the attractiveness of the competition it was decided to offer money prizes, medals, and, if possible, travelling scholarships, while in cases of very exceptional merit, it was proposed that the Society should confer its Diploma which, it is hoped, will soon come to be recognised as the hall-mark of a first class designer. The Committees further decided to hold exhibitions of the selected designs in London and possibly in other suitable centres, in order that the competitors might have their work brought prominently to the notice of manufacturers most likely to be interested in it.

About a year ago the various committees issued appeals for funds, with the

gratifying result that over £1,000 was subscribed, almost entirely by manufacturers, to provide scholarships and prizes at the 1924 competition. Unfortunately, it was not found possible to hold a competition in architectural decoration this year, although it is hoped that this defect may be remedied in 1925; but a Miscellaneous Section was added in which substantial prizes were offered by two well-known firms.

Particulars of the First Competition were issued and widely circulated at the end of 1923. The subjects of competition and prizes offered were as follows:—

Conditions of the Competition.

Textiles.

Designs for the following:—

(1) Carpets and Rugs.
Moquettes.
Floor Coverings: Linoleum and Floor Cloths.

(2) Tapestries.
Damasks, Brocades and Figured Velvets for Furniture and Decoration.

(3) Printed Fabrics for Hangings and Furniture.
Printed Fabrics for Dress.

(4) Vestments.
Church Fabrics, including Altar Frontals, etc.

(5) Dress Brocades and Fancy Dress Fabrics.

(6) Lace; Lace Curtains.
Embroidery.
Open Work.

(7) Handkerchiefs.
Tie Silks and Mufflers.
Ribbons and other narrow goods.

(8) Bedspreads.
Table Damasks.
Cushion Squares.
Tea Cosies, etc.

Candidates may submit designs for any or all of the items in any or all of the foregoing groups.

Prizes offered: The contributions to the Prize Fund are sufficient to allow of the award of one, or possibly more, Travelling Scholarships to candidates of outstanding ability. The course of study to be followed by the successful candidates will be decided after consultation between them and the Judges.

Money Prizes of not less than £10 10s. each will be awarded in each of the groups (1)—(8) at the discretion of the Judges.

Furniture.

The subjects of competition are as follows:—

(1) Designs for the complete Furniture of a Modern Dining Room decorated in Adam Style.

(2) Designs for the complete Furniture of a Modern Bedroom, without reference to traditional style.

(3) Designs for the complete Furniture of a Modern Sitting Room, without reference to traditional style.

(4) Designs for a Dresser, Table and Chair suitable for a Working-man's Living Room.

(5) Design for a Toilet Table in a simple style.

(6) Design for a Bookcase 6 feet long.

(7) Design for a Broadcasting Cabinet or a Gramophone Cabinet.

(8) Designs for a Garden Table, Seat and Chair.

Prizes offered: A Travelling Scholarship of £125 is offered for the best set of designs submitted in groups (1)—(3).

A Prize of £10 is also offered for the best set of designs in each of the groups (1)—(3), and a prize of £5 for the best design in each of the groups (4)—(8).

Book Production.

The subjects of competition are as follows:

(1) Design for a new Type Face (12-point Pica, Roman, not Italic), including Alphabets in Capitals and Lower Case, Figures and Punctuation Marks. The size of the drawings to be not less than 4, and not more than 5, diameters.

(2) Designs for either or both of the following:—(*a*) A Title Page entirely set from type, with or without Printers' ornaments; (*b*) a Title Page partly decorated. The Title Pages to be taken from any or all of the following:—
(*a*) "The History of Tom Jones, Foundling," by Henry Fielding. (Size, Demy Octavo.)
(*b*) "On the Morning of Christ's Nativity," by John Milton. (Size, Crown Quarto.)
(*c*) A Scientific Paper. (Size Demy Octavo.)

The copy in each case will be supplied by the Royal Society of Arts.

(3) Designs for Three Pages of Text, with Chapter Heading, from any or all of the books enumerated in Section 2 above, and in the sizes respectively indicated there.

The copy for (c) will be supplied by the Royal Society of Arts.

(4) Designs for any or all of the following:
(a) A Line Illustration.
(b) A Colour Illustration.
(The subject of the design must be taken from a well-known book, *e.g.*, one included in the *World's Classics* or *Everyman's Library.*)
The size of the design must not exceed 12 in. by 10 in.

(5) Design for an End or Cover Paper.

(6) Design for a Binding for "The Water Babies," by Charles Kingsley, in (a) Cloth (blocked), and/or (b) Leather (tooled).

Prizes offered: A Prize of not less than £10 10s. is offered for each of the subjects set forth above.

POTTERY AND GLASS.

The subjects for competition are as follows:—

China.

(1) Designs for a Tea Cup and Saucer, with decoration suitable for either engraving enamelling or lithographing; with or without gilding, and with or without grounds.

Earthenware.

(2) Designs for a Dinner Plate and Vegetable Dish, with decoration suitable for either engraving, enamelling or lithography; with or without gilding.

Glass.

(3) Designs for a Service of Glass (*i.e.*, a Wine Glass, a Tumbler and a Decanter) in plain form or with decoration suitable for etching, engraving or cutting.

(4) A design for either a Flower Vase or a Flower Bowl for table decoration, either in plain form or with decoration suitable for cutting.

(5) A design for a Dish or Bowl in pressed glass.

Prizes offered: First Prizes of not less than £10 10s. each will be offered in connexion with each of the groups (1)—(5). The copyright of the designs will remain the property of the successful candidates, who will also be afforded special facilities for selling their designs to the Manufacturers' Associations interested.

MISCELLANEOUS.

CADBURY BOURNVILLE TRAVELLING SCHOLARSHIP.

Messrs. Cadbury Brothers, Ltd., offer a Cadbury Bournville Travelling Scholarship of £50 in each of the four years 1924-7. The winner will be required to travel on the Continent of Europe for the development of his or her art.

The subjects for competition are any or all of the following:—

(1) A Poster.
(2) An Illustration for the Press.
(3) A Pictorial Design for a Box Lid.

SPECIAL PRIZES FOR CHOCOLATE BOX DESIGNS.

Messrs. J. S. Fry & Sons, Ltd., of Bristol, offer the undermentioned prizes for designs for Chocolate Boxes:—

(1) A design in four or five colours suitable for the Lid of a Display Box, including lettering. The subject of the design of label to be appropriate to the proposed title. Size not to exceed 11 ins. by 7 ins.

First Prize	..	..	£25
Second Prize	..	..	£10

(2) A colour design adapted for the Cover of a 1-lb. Box with Side Panels. Size not to exceed—Top panel, 8 ins. by 6 ins.; Side panel $1\frac{1}{2}$ ins. deep.

First Prize	..	..	£25
Second Prize	..	..	£10

(3) A design in colours appropriate to the name "Somerdale." Size not to exceed 11 ins. by 7 ins. Special attention to be given to the style of lettering.

First Prize	..	..	£25
Second Prize	..	..	£10

The awards will be subject to the undermentioned conditions:—

(a) The Judges to be appointed shall be three in number, of whom two shall be appointed by the Royal Society of Arts and one by Messrs. J. S. Fry & Sons, Ltd.

(b) The prize-winning designs shall be the property of Messrs. J. S. Fry & Sons, Ltd.

(c) The designs submitted should be of a character that would be understood and appreciated by the general public.

(*d*) Messrs. J. S. Fry & Sons, Ltd., will supply dummy boxes required.

"OWEN JONES" PRIZES.

In addition to the prizes mentioned above, the Council offer six Bronze Medals under the "Owen Jones" Trust to candidates in Class (*a*) Students in British Schools of Art.

Thanks to the kind assistance of the Director, Sir Cecil Harcourt Smith, C.V.O., the Society received permission to judge the designs and afterwards to exhibit selected specimens at the Victoria and Albert Museum.

RESULTS OF THE COMPETITION.

The number of candidates who entered in all sections of the competition was 553. Of these 344 were students of Schools of Art and 209 non-students. The number of designs submitted was 1,408, divided as follows:—

Textile Section		538
Furniture Section		108
Book Production Section		214
Pottery and Glass Section		104
Miscellaneous Section—		
Prizes offered by Messrs. J. S. Fry and Sons, Ltd.	342	
Travelling Scholarship, offered by Messrs. Cadbury Bros., Ltd. ..	102	
		444
		1408

The Schools of Art from which candidates entered were :—

[The numbers in brackets show the number of candidates from each school.]

Batley (1); Bath (2); Battersea (7); Belfast (4); Birkenhead (2); Birmingham (Birchfields Branch School) (4); Blackburn (6); Bournemouth (22); Bradford (3); Camberwell (1); Carlisle (8); Colchester (2); Coventry (3); Croydon (6); Darlington (9); Derby (10); Dewsbury (3); Doncaster (2); Dublin(2); Edinburgh (1); Farnham (1); Glasgow (1) Glossop (4); Godalming (1); Goldsmiths' College, London (4); Great Yarmouth (1); Guildford (2); Hammersmith (9); High Wycombe (2); Hornsey (28); Ipswich (1); Keighley (3); Kendal (2); Kingston-on-Thames (2); Lancaster (7); Leeds (9); Lewes (2); Leyton (16); Liverpool (21); L.C.C. Central School of Arts and Crafts (3); Macclesfield (19); Manchester College of Technology (2); Manchester School of Art (15); Nottingham (5); Paignton (1); Penzance (1); Putney (1); Rochester (1); Royal College of Art (1); Sheffield (16); Southend (3); Southport (10); Sutton, Surrey (1); Todmorden (1); Torquay (4); Watford (24); West Bromwich (13); Worcester (2); Wordsley (7).

The Judges were appointed by the Council of the Society on the recommendation of the various Sectional Committees. Their names are as follows :—

TEXTILES.

Sir Frank Warner, K.B.E., Chairman of the Textile Section Committee,—Peter Adam, Esq., G. P. Baker, Esq., T. C. Dugdale, Esq., Lady Horner, O.B.E., A. F. Kendrick, Esq., Thorold D. Lee, Esq., C. E. C. Tattersall, Esq., and A. Herbert Woolley, Esq.

(Professor R. Anning Bell, R.A., and Sir Banister Fletcher, F.R.I.B.A., were also appointed judges, but were unable to attend.)

FURNITURE.

W. Nelson Bridges, Esq., C. A. Richter, Esq., H. D. Searles-Wood, Esq., F.R.I.B.A., L. A. Shuffrey, Esq., and W. Stewart Greene, Esq.

(Sir Banister Fletcher, F.R.I.B.A., Ambrose Heal, Esq., and J. Murray Reid, Esq., were also appointed judges, but were unable to attend.)

BOOK PRODUCTION.

J. A. Milne, Esq., C.B.E., Chairman of the Book Production Section Committee, Laurence Binyon, Esq., LL.D., F. V. Burridge, Esq., R.E., A.R.C.A., F. J. Hall, Esq., George W. Jones, Esq., Major R. Leighton, C.J. L'Estrange, Esq., James Maclehose, Esq., LL.D., F.S.A., G. H. Palmer, Esq., A. W. Pollard, Esq., C.B., D.Litt., F.B.A., and Emery Walker, Esq.

POTTERY AND GLASS.

E. R. Edis, Esq., Chairman of the Pottery and Glass Section Committee, Percy Brooks, Esq., Harold Plant, Esq., E. J. Purser, Esq., Bernard Rackham, Esq., W. Savill, Esq., and Herbert Webb, Esq.

CADBURY-BOURNVILLE TRAVELLING SCHOLARSHIP.

F. V. Burridge, Esq., R.E., A.R.C.A., and J. A. Milne, Esq., C.B.E.

PRIZES OFFERED BY MESSRS. J. S. FRY AND SONS, LTD.

F. V. Burridge, Esq., R.E., A.R.C.A., R. L. Hanover, Esq., and J. A. Milne, Esq., C.B.E.

The judges met at the Victoria and Albert Museum on July 1st, when they examined the work submitted, and drew up the following Reports :—

TEXTILES.*

SUB-SECTION 1, including carpets and rugs; moquettes; floor coverings; linoleums and floor cloths.

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* In the conditions of the Competition set forth above, the Textile Section was divided into eight Sub-Sections. For the purposes of judging it was divided into five Sub-Sections.

The designs in this section are comparatively few in number, and of no special merit.

The carpet design No. 192 (the work of James Aitchison, Glasgow School of Art) contains some original features. The border is a little weak and out of tune with the centre. The colour is good.

Two designs for floor coverings, No. 90 (the work of Thomas Forret), are fair examples of students' work.

No prize is awarded in this section.

Sub-Section 2, including tapestries; damasks; brocades and figured velvets for furniture and decoration; vestments; church fabrics, including altar frontals, etc., and table damasks.

A prize of £10 10s. is awarded to Eric Edward Taylor (School of Arts and Crafts, Battersea Polytechnic) (No. 551) for a design for a tapestry panel.

Prizes of £5 5s. each are awarded to :—

Miss Doris Duckworth (City School of Art, Liverpool) (No. 327) damask table cloth.

Miss Rebecca Viney (School of Art, Farnham) (No. 114), for the promise of her work, but not the execution, and for general merit in the Textile Section.

The following are commended :—

Herbert Woodman (No. 432).

Miss Marjorie E. Brown (School of Art, Torquay) (No. 63).

Sub-Section 3, including printed fabrics for hangings and furniture; bedspreads; cushion squares; tea cosies, etc.

A prize of £10 10s. is awarded to Miss Eleanor Joan Palmer (Municipal School of Art, Manchester) (No. 162), cretonne hanging.

A prize of £5 5s. is awarded to James Hanson (School of Art, Technical College, Blackburn) (No. 147), cushion square.

The following are commended :—

Miss Ethel M. Bennett (No. 224).

Miss T. M. Bowyer (No. 441).

William James Grout (Correspondence College for Applied Design, Nottingham) (No. 396).

Miss Gertrude Mary Harris (No. 29).

Miss Winifred Mee (Municipal School of Art, Manchester) (No. 159).

Miss Phyllis Ramage (Municipal School of Art, Manchester) (No. 161).

Miss Mary Stansfield (Municipal School of Art, Manchester) (No. 160).

Sub-Section 4, including printed fabrics for dress; dress brocades and fancy dress fabrics; handkerchiefs; tie silks and mufflers; ribbons and other narrow goods.

Printed Dress Fabrics.—A prize of £10 10s. and an Owen Jones bronze medal are awarded to Miss Elizabeth Wilson-Haffenden, Croydon School of Art, for design 3 on the sheet No. 301. This design is good technically and excellent both in *motif* and colour. The other two designs on the same sheet are poor in colour.

The following designs are commended :—

No. 442. Print for voile. Miss Elsie McNaught.

The *motif* and colour are good, but the design is not very accomplished technically, and the work should be more careful so that the engraver may understand clearly what is intended and what is merely accidental.

No. 371, by Miss Joyce Gregory, Hornsey School of Art.

The design is pleasant and gay in colour.

The rest of these designs show a moderate average of technical knowledge and of facility in execution. Instead of using bright schemes the competitors' sense of colour seems to be dulled. A study of old colour prints and old colour brocades, especially of the specimens in the Victoria and Albert Museum, is strongly recommended. Much more attention should be given to good drawing of *motifs*. In many cases this is too mechanical and uninteresting. The purpose for which the material is to be used should be kept constantly in mind when the design is being made. In one case only (No. 283) is direct evidence given that the idea of dress is conceived before the pattern is made, and a prize of £5 5s. is awarded to the designer, Miss Kate Muriel Gee.

Woven Dress Fabrics.—In this section, although some of the designs are satisfactory from a weaving point of view, the *motifs* are very uninteresting, and the colour generally is muddy and dull.

Fancy Dress Fabrics.—Amongst these works there seems to be no sense of gaiety of colour or suitable design. Some idea of

the fancy dress in the mind of the designer might be submitted with the design.

Handkerchiefs, Tie Silks, etc.—This part of the competition is distinctly bad. The technical qualities are poor and the artistic qualities very poor.

There seems to be but little indication in the work submitted that students are made familiar with the trend of fashion. This is a most important factor in designing any dress fabric, as, after all, tradition is the outcome of a series of fashions, and fashion has at the present time a great influence on the type of design necessary.

The judges feel strongly that this first competition instituted by the Royal Society of Arts should be dealt with very seriously, for the regrettable gulf which has opened between art and manufacture must be bridged without delay if this country is to regain her pre-eminence in commerce.

SUB-SECTION 5, including lace; lace curtains; embroidery and openwork.

Prizes of £10 10s. each are awarded to:

Mrs. Ella Hodgett (School of Art, Glossop), No. 346, Lace bedspread.
Miss Gladys Ruth Adams, No. 217, Embroidered blouse.

Prizes of £5 5s. each are awarded to:

Miss Daisy Rogers Stedman (Correspondence College for Applied Designs, Nottingham), No. 401.

Miss Jane Kirkbride (School of Art, Storey Institute, Lancaster), No. 257.

Commended:

Miss Doris Cook (Hornsey School of Art) No. 370.

The designs submitted in this sub-section were few, and none except those mentioned above call for special mention.

FURNITURE.

The following awards are recommended:

(1) Design for the complete furniture of a modern dining room decorated in Adam style.

Prize of £10 and an Owen Jones bronze medal: Herbert Stanley Froude (School of Art, Goldsmiths' College) (No. 429).

Commended: Duncan M. Grassie (No. 227).

(2) Design for the complete furniture of a modern bedroom, without reference to traditional style.

Prize of £10: Edward Herbert Hill (No. 292).

Commended: Harry Norris, jun. (No. 447).

(3) Complete furniture of a modern sitting-room, without reference to traditional style.

Prize of £10: Edward Herbert Hill (No. 292).

Commended: Sidney Leonard Neale (No. 298).

(4) Dresser, table and chair suitable for a working man's living room.

Prize of £5: Edward Herbert Hill (No. 292).
Commended: James Edward Crane (No. 237).

(5) Toilet table in a simple style.

Prize of £5: Edward Herbert Hill (No. 292).

(6) Bookcase.

Prize of £5: Patrick Casey (School of Art, Barnstaple) (No. 17).

Commended: Frederick Sidney Maude (School of Art, Ipswich) (No. 234).

(7) Broadcasting cabinet or gramophone cabinet.

Prize of £5: James Edward Crane (No. 237).

Commended: Edward Herbert Hill. (No. 292).

(8) Garden table, seat and chair.

Prize of £5: Patrick Casey (No. 17).

The Travelling Scholarship of £125 is awarded to Edward Herbert Hill.

BOOK PRODUCTION.

1. NEW TYPE FACE.

There is some evidence that the few competitors for this prize have looked at modern Roman alphabets but little to show that they have profited by the study. The designs sent in are wholly unsuited as copy for the engraving of type punches for the production of type for the printing of books, and no jobbing printer who respected his work would use them if they were. The truth is, type design is rather too difficult a job for an amateur and only these apparently have competed.

The competitors have not understood that only the most trifling variations from the established forms are possible. The standard set by the Venetian printers of the fifteenth century, the French printers of the sixteenth, and our own Caslon of the eighteenth century, are, if not the last word in Roman letter, hardly to be departed from with impunity. All types based on these forms or even those of Didot and Bodoni, the progenitors of our "Modern" face, are eminently *readable.* Readability and not eccentricity should be the aim of the type designer in addition to as much beauty as he can compass.

It is with regret that the judges can make no award.

2. TITLE PAGES.

Prize of £10 10s.: Peter Carruthers (No. 100).

Highly commended: T. F. Garside (Manchester School of Technology) (No. 541).

3. SETTING OF THREE PAGES OF TEXT.

No awards are recommended in this sub-section.

4. LINE AND COLOUR ILLUSTRATIONS.

The judges do not consider that any of the work in this sub-section shows the least attempt to respond to the call for that advance in the standard of work which it was hoped would result from this competition, and they recommend that the prize of £10 10s. be not awarded. They desire, however, to commend generally the work of the Hornsey School of Art, and they recommend that an Owen Jones bronze medal be awarded to Miss Lorna Steel.

In the sub-section of colour illustration, they commend the work of George Whitfield Dix (No. 449).

5. END OR COVER PAPER.

Prize of £10 10s.: Miss Evelyn Gwendoline Maw (L.C.C. Central School of Arts and Crafts), No. 77.

6 (*a*) CLOTH BINDING.

Commended: Miss Ellen M. Woodward-Reid (No. 424).

6. (*b*) LEATHER BINDING.

The judges recommend that the prize of £10 10s. be equally divided as follows:—

Prize of £5 5s.: Miss Mary G. Gibson (No. 225).

Prize of £5 5s.: Francis Glanville Garrett (No. 212).

Commended: Miss Hazel M. Montgomery (City School of Art, Liverpool), No. 340.

POTTERY AND GLASS.

POTTERY.

The judges call attention to the almost complete lack of originality in the designs submitted. There is too strong a tendency to cling to present and past practice, and no suggestion of fresh ideas.

Many of the shapes are not practicable from the standpoint of utility or of potting. Handles on cups and tureens are either too large or too small. Saucers are too flat to fire safely, and tureens too shallow for use. In many cases handles are so placed and drawn as to invite breakage. In one case the tureen is without handle at all.

Beauty of outline is not sufficiently in evidence.

The designs for dinner services are particularly disappointing. They are mostly overdone, and differ but little from what has been on the market for the last twenty years.

China: designs for a tea cup and saucer.

Miss Kathleen Waine (No. 86A) is commended and recommended for an Owen Jones bronze medal.

Earthenware.

No awards are recommended in this sub-section.

William Frederick Godfrey (No. 427) shows distinct merit, but his entry is not complete, and does not fulfil all the conditions of the competition. He has a good idea of constructing a pattern, but the tendency towards over elaboration should be controlled, especially in pottery.

GLASS.

The judges consider that in this sub-section the designs in general are encouraging, and that the competitors have given careful thought to the requirements of the material and its manufacture.

They recommend that a prize of £10 10s. be awarded to Reginald Edward Edgecombe (No. 230) whose work shows great merit and mastery of the technique of the processes of manufacture. In some of his designs he has not given sufficient attention to the cost of production, and in one case, a bowl, the fragility of the top is unsuited

for practical use in present-day conditions.

Of the students, the work of Leonard Green (Wordsley School of Art) (No. 153) is very meritorious, and he is recommended for an Owen Jones Bronze Medal. The design for a cut table service is effective, and the pressed bowl is also good, the scalloping of the edge being satisfactory, without the fault of fragility.

MISCELLANEOUS.

CADBURY BOURNVILLE TRAVELLING SCHOLARSHIP.

Mr. Rowland Frederick Hilder (No. 312) (School of Art, Goldsmiths' College), exhibited work in all three parts of this section, viz., a poster, an illustration for the press, and a pictorial design for a box lid, and his work was the best in all three. The judges consider him to be a very promising young artist, and recommend that he be awarded the Cadbury Bournville Travelling Scholarship of £50 for 1924, and also an Owen Jones Bronze Medal.

Miss Kathleen Ardern, poster (Sheffield School of Art), (No. 117) is commended.

PRIZES FOR CHOCOLATE BOX DESIGNS OFFERED BY MESSRS. J. S. FRY & SONS, LTD.

The competition did not produce work of sufficiently high standard to justify the award of the full prizes of £25, which were offered by Messrs. J. S. Fry & Sons, Ltd. Several designs, however, showed considerable merit, and the following awards are made :—

(1) For a design in four or five colours suitable for the lid of a display box :—

Prize of £10 : Maurice Campbell Taylor, (Bradford School of Art) (No. 489).

Prizes of £5 each : Mrs. Dorothy Mary Stanford (No. 20).

F. W. Sheppard (Leeds School of Art) (No. 319).

Leo Hardy (Sheffield School of Art) (No. 480).

(2) Colour design for cover of a 1 lb. box :—

Prizes of £5 each: Frederick Angus Horn (Bradford School of Art). (No. 543).

William Richard Pearson (No. 423).

Miss Antonia Young Hall (School of Art, Bournemouth) (No. 133).

(3) Design in colours appropriate to the name "Somerdale" ;—Prizes of £5 each:

Ernest Male (City School of Art, Liverpool) (No. 333).

Walter McDade (No. 405).

Mrs. Dorothy Dix (No. 448).

William Knight (No. 37).

On the whole, the judges consider that the results are satisfactory, especially when it is borne in mind that this year the competition is being held for the first time. The number of designs submitted in all the sections was 1,408, and this would no doubt have been very considerably increased if it had been found possible to include the subject of architectural decoration. With regard to the quality of the work, in no case did it reach the diploma standard, and the judges were able to award only one of the three travelling scholarships which were offered ; but although in some sections the results were disappointing, in others, especially in certain sub-sections of Textiles, Furniture and Glass, several of the designs showed considerable promise. The committees hope that those candidates who have received prizes or commendation will be encouraged to devote themselves more eagerly to their work, and to produce still better designs at future competitions. They trust, also, that as the competitions become more widely known the number of candidates will increase and the quality of the designs will improve. If the best of our young designers can be induced to send in their work to these competitions, there is little doubt that manufacturers will soon begin to look to the exhibitions when they require the services of a first-class designer.

In announcing the awards, the Council desire to express their thanks to the Judges for the care which they have devoted to the work, and for the promptitude with which the awards have been made.

They wish also to state their warm appreciation of the assistance rendered to the Society by the Director of the Victoria and Albert Museum and his staff.

An Exhibition of the Designs submitted in the Competition was opened in the North Court of the Victoria and Albert Museum, South Kensington, on July 26th, and will remain on view until August 30th next, daily from 10 a.m, to 5 p.m., and on Thursdays and Saturdays from 10 a.m. to 9 p.m.

The full conditions and arrangements for the Competition in 1925 will be announced later.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

MONDAY, JUNE 30TH, 1924.

THE RT. HON. THE EARL OF RONALDSHAY, G.C.S.I., G.C.I.E., in the chair.

THE CHAIRMAN said the Society was fortunate in having secured Mr. J. C. French to read a paper on the art of the Pal dynasty. Mr. French had spent the greater part of his working life amongst the people of India, and had acquired a very genuine interest in and love for their civilisation and culture. During his (Lord Ronaldshay's) period of office as Governor of Bengal Mr. French occupied many important official positions, and was in charge of the largest and most populous district in Eastern Bengal, the district of Mymensingh, at a time when political agitation certainly did not make the lives of district officers specially happy. But, in spite of all Mr. French's troubles and difficulties, he never permitted them to alienate his sympathies from the people amongst whom he lived, or in any way to affect his admiration for their culture; and he had made a close personal study of the subject about which he was going to speak that afternoon. No one, therefore, could be better qualified to deal with what was admittedly a little-known subject—namely, that of the art of the great Pal Empire of Bengal, which covered a period of some three centuries or so, from the 8th century A. D. onwards.

The paper read was :—

THE ART OF THE PAL EMPIRE IN BENGAL.

By J. C. FRENCH, I.C.S.

I should like to mention that this lecture is concerned with art, and not with history. But a certain historical setting is necessary, as it is difficult to treat of an art coming completely out of the void. For the history of the Pal Empire I am principally indebted to the work of the late Mr. F. J. Monahan, of the Indian Civil Service, that distinguished scholar and historian under whom I had the honour to serve as a District officer in the Presidency Division of Bengal.

The Pal dynasty reigned in Bengal during the Dark Ages in Europe, from the 8th to the 11th centuries. The flood of the Mohammedan invasion lies between us. Their only relics are the vast mounds which mark their buried cities, and the art which is our present subject.

The rise of the Pal dynasty in Bengal was preceded by a period of anarchy. From the obscure chronicle of the Rama Charitam we learn that to end this anarchy "the people forced the Goddess of Fortune on Gopala." This Gopala was the first King of the Pal line. He came to the throne by election, and we are told that he was chosen King to put an end to a condition of things described by the Sanskrit word "matsyanyayam." The literal translation of this word is "fishy." It is not an anticipation of modern slang, but is a favourite simile of ancient Sanskrit writers on political science. Anarchy is said to be fishlike because the large fish prey at will on the smaller ones. Efforts to end this anarchy in Bengal were for a time futile. The Tibetan lama Taranath in his History of Buddhism gives the reason as follows: "The widowed queen of a former King of Bengal murdered with poison everyone who was chosen to be King, but after a certain number of years Gopala was elected. He eluded her efforts to poison him, and became King for life." This story would seem fantastic to European ears, but it is exactly paralleled in our own times in Tibet. The present Dalai Lama, the ruler of Tibet, is the first for some hundreds of years to reign for any considerable length of time. All his predecessors were poisoned. Like Gopala, the present Dalai Lama has eluded his poisoners. The throne to which Gopala was elected was that of Gauda. This name is now applied to the ruins of a a great city in the Malda District, but in ancient times it included the whole of Northern Bengal. Gopala extended his sway over the neighbouring Kingdom of Magadha, now known as South Bihar. Gopala was by religion a Buddhist, but, like his successors, he tolerated and even endowed Brahminism, and the two religions existed in peace side by side. A line in the chronicle of the Rama Charitam describes Gopala as "sea born." What is the exact meaning of this picturesque phrase, whether it suggests the claim of a divine descent from the gods of the sea, or is merely a poetical expression of a foreign origin of the dynasty, who crossed the sea to Bengal, it is impossible to say.

This is an example of the art of the beginning of the Pal dynasty. It is an image of the goddess Chandi, and bears an inscription which gives its date as the end of the 8th century. This image was found in the district of Tippera in Eastern Bengal, and was seen by the writer in a temple of Chandi, in the south-west extremity of the Lalmai Hills, a peculiar low range rising abruptly from the alluvial plain.

Now this image has disappeared, stolen by thieves. It was a metal image, in an amalgam known in India as *ostradathu*, the sacred mixture of the eight metals, including gold and silver. Doubtless it has been melted down for the fragments of precious metals which might be found in it. The photograph hardly does justice to the image, and the profile view was even finer, but such as it is we must make the best of it, as the only surviving record of this most interesting work. The simplicity, dignity, and a certain immanent sense of life and significant vitality need no emphasis. For this photograph and for many succeeding ones, I am indebted to Mr. Nalini Kanta Bhattashali, the able and zealous curator of the Dacca Museum. I am also indebted to his indefatigable researches into the ancient history and archaeology of Bengal.

This small figure of Avalokitesvara is an example of the art of Bengal in the 8th century. It was also found in the Lalmai Hills, near Comilla, some years ago. It is now on exhibition in the Indian Pavilion at Wembley.

This magnificent image of Vishnu comes from Barisal. The force and power and sense of profound depth and mystery are apparent. The style in some ways recalls the Gupta period, but the mysterious and significant vitality, and the tense and nervous energy pervading the figure mark it as a fine example of the splendid period of Indian art which lies between the Hun and Mohammedan invasions. Judging from the style, this image cannot be assigned a later date than the 8th century.

This is an image of Vishnu. It is now on exhibition in the Indian Pavilion at Wembley. The elegance and strength of this figure, combined with the same mysterious sense of vitality which marks the first figure of the goddess Chandi, are characteristic of the early stages of Pal art. The perfect simplicity and restraint of the setting and scheme of decoration strike the eye, especially when contrasted with the florid over-elaboration so often associated with later images of this character. The style of the art resembles that of the first figure of the goddess Chandi. This image was found on the site of the ancient city of Mahasthan. All that remains of Mahasthan nowadays is a plateau a mile square, surrounded by a vast moat. The plateau supports an ordinary Indian village with its rice and brilliant yellow mustard fields, and only a vast pillar or massive block of stone protruding from the earth recalls the memories of its vanished glories. This plateau, which rises straight up from the plain, and is the work of man and not of nature, is an enduring evidence of the power and greatness of the Pal Empire. All the region round Mahasthan for some miles is full of traces of ancient remains. It resembles Delhi, Patna, and Malda in that it contains ruins and remains not merely of a particular period, but of several distinct epochs. For instance, the Chinese traveller Hieun Tsiang visited Paundra-vardhana in the 7th century, and later on Ramapala established his capital of Ramavati here. If but one hundredth part of the time and energy expended every year on excavations in Egypt were applied to this region, what interesting results might not be obtained!

In one corner of the plateau of Mahasthan stands a Mohammedan mosque. The ancient Hindu carvings and figures on the walls, and even in the stones of the steep flight of steps which lead up from the plain, bear witness to the iconoclastic zeal of its architects, and recall the days, evil to Hindu art and sculpture, of Kala Pahar and his image breakers. Kala Pahar, according to local tradition in Central Bengal, was a Brahmin, who joined the Mohammedans when they invaded Bengal, and in the destruction of images and temples showed the zeal of a convert.

Gopala was succeeded on the throne by Dharmapala, whose reign falls in the first half of the 9th century. This sovereign extended his empire far over Northern India. He conquered the Kingdom of Kanauj, deposed the King, and set up a vassal in his place. He was a reformer of the Buddhist religion. Dharmapala married a Rashtrakuta princess. The Rashtrakutas occupied the Deccan and Dharmapala sometimes allied with them in his wars against the Gurjaras, who occupied Rajputana and the Punjab. A poet described him as follows: "King Dharmapala is like to the Kalpataru (the Kalpataru is the wishing-tree of Hindu legend, that gives whatever is asked of it). What shall I say of him who is devoted to his faith, rules the earth, and is descended from the Ocean, who has the Moon for his friend?" Dharmapala was famous for his modesty. He turned away his head in confusion when he heard his praises sung by the village

cowherds, by the children at play, and even by the parrots in their cages.

Dharmapala was succeeded by Devapala, a warlike King, whose war elephants penetrated the Vindhya Mountains, and his war horses visited their native home in the country of the Kambojas. The lord of Utkala, hearing Devapala's name from afar fled, while the lord of Pragjyotisha, accepting Devapala's commands, remained in peace and friendship. Devapala humbled the pride of the Huna, the Dravida, and the Gujara Kings. (The phrase of the war horses visiting their native homes in the country of the Kambojas appears obscure, but the explanation is simple. The country of the Kambojas is Tibet. Even nowadays there is a trade in horse-flesh from Tibet and the Himalayas into Bengal. The expression indicates that Devapala mounted his cavalry with horses imported from Tibet. So when he invaded Tibet the horses of his cavalry visited their native home). An inscription on a pillar tells us: "The illustrious prince Devapala made tributary the earth as far as Reva's parent, whose rocks are moist with the blood of wild elephants, as far as Gauri's father, the mountain whitened by the rays of Isvara's moon, as far as the two oceans whose waters are red with the rising and the setting sun."

It was in Devapala's reign that there flourished the only two artists whose names have come down to us, Dhiman and his son Bitpalo. Taranath in his history of Buddhism tells us:—

"In the time of King Devapala there lived in Varendra (Northern Bengal) an exceedingly skilful artist named Dhiman, whose son was Bitpalo; both of these produced many works in cast-metal, as well as sculptures and paintings which resembled the works of the Nagas. The father and son gave rise to distinct schools. In painting the followers of the father were called the Eastern school; those of the son as they were most numerous in Magadha, were called followers of the Madhyadesha school of painting. So in Nepal the earlier schools of art resembled the old Western school; but in the course of time a peculiar Nepalese school was formed, which in painting and casting resembled rather the Eastern types."

The mention of the influence of this Pal art on the art of Nepal, which continues to the present day, is interesting.

The reigns of these two Kings occupied the greater part of the 9th century. The following images are examples of the art of this period.

This is an image of the Buddhist goddess Tara. It is from a village in the district of Dacca. This image from the style of the art can be assigned to the 9th century. It conveys a distinct reminiscence of the period of Indian art sometimes known as Early Buddhistic, which includes the sculptures of the Asokan age, of Bharut, and of Sanchi. The essential continuity of Indian art is well exemplified in this figure.

This image of the Buddhist Bhairaba is also assignable to the 9th century. Like the preceding image, it comes from Eastern Bengal (Tippera district). It represents Heruka, the Buddhist Bhairaba, a terrific manifestation invoked to ward off calamities. The image wears a garland of skulls and is engaged in a ritual dance.

This is an image of a Buddhist goddess. The image was found at Mahasthan, and is at present in the museum of the Varendra Research Society. I am indebted to the distinguished and learned Secretary of that society, Mr. Akhoy Kumar Maitra, for this photograph, and also for much information concerning the history and art of this period. In this image, the art appears in a gentler and more gracious form. The whimsical and fantastic grace of the supporters form a fitting foil to the dignity and beauty of the central figure.

This small metal seated figure of the Buddhistic Lokesvara comes from the district of Dacca. Lokesvara is identical with Lokanatha the Bodhisatva of Amitabha. It is assignable to the same period as the preceding figure.

The next six kings of the Pal dynasty after Devapala are mere names, and it is not until we come to Mahipala, famous in Bengal song and story, that the mists of a thousand years clear for a moment. His accession is placed late in the 10th century. Mahipala recovered the kingdom of his ancestors, which had been encroached upon by a Tibetan invasion. Tradition ascribes to him great public works, but all that remain of them nowadays are tanks so vast as to resemble lakes and mounds and ruins. A saying is still current in Bengal which preserves his name: "Dhan bhante Mahipaler gita."—"Songs of Mahipal while husking rice." Mahipala repulsed Rajendra Chola, an invader from Southern India. Mahipala in 1026 A.D. did extensive repairs

to the temples and shrines in Benares. The beginning of the vernacular literature of Bengal is ascribed to this reign. Buddhist songs in Bengali gave rise to the Kirtana songs. Mahipala was the greatest power in Northern India. It was a period of religious development, in which popular Buddhism came to be influenced by the doctrines of Tantras. "Nathas" flourished about this time. These "Nathas" were ascetics who, by the exercise of Yoga, attained to superhuman powers. They were both Buddhists and Saivas.

This figure of Shiva bears the date of the third year of Mahipal's reign, about the beginning of the last quarter of the 10th century, and is a fine example of the art of the Pal period. Carved in bas-relief on extremely hard and polished black rock, it must have taken about two years to complete. Such statues are practically indestructible from natural causes, and will yield only to the hammer of the fanatical image breaker. Below the statues on either side are the shaktis or personifications of the female energies of the deity. On either side of the deity's arms are lions, the emblems of knowledge. They are usually shown mastering elephants, as signifying the triumph of knowledge over ignorance, a somewhat singular inversion of the general idea of the intelligence of elephants. In this statue, of course, the elephants are omitted, but they are shown in a later example. At the top of the statue are the flying apsaras, while at the foot are the figures of the donor of the statue and his family.

This magnificent image of Tripura comes from the Dacca District. Tripura is the female creative principle of the universe. It is impossible to conceive a finer expression in art of profound and unfathomable meditation. This is a Brahminical image.

This is an image of Jambhala, the Buddhist god of riches. Jambhala is derived directly from the Brahminical deity Kuvera, the head of the Yakshas, and the god of ghosts and the under-world, including buried treasure. But Jambhala with his conversion to Buddhism changed his character, and we find him resembling another god of the Hindu pantheon, the elephant-headed Ganesh. Ganesh is the god of successful endeavour, of righteous increase, the apotheosis of the profiteer. The favour of Kuvera, resulting in accession to sudden and sinister wealth, was by no means so sought after by the wise as were the benefits of Jambhala and Ganesh.

This charming image of a form of Buddha comes from Western Bengal. The delicacy and grace of the art need no emphasis.

This fine image also comes from Western Bengal. It represents Pindola, a contemporary of the great Buddha, and subsequently deified as the god of medicine.

Mahipala's reign appears to have continued for the first thirty years of the eleventh century. The principal event in the reign of his successor Nayapala is the mission of Atisa to Tibet. Atisa was a principal lama in the Buddhist monastery of Vikramasila on the Ganges. Envoys came from Tibet and persuaded him to go to that country to reform the Buddhism there. It was about the year 1040 A.D. that Atisa said farewell to Sthavira Ratnakara, the head of the Vikramasila monastery. The latter was much dejected, and said that the signs promised evil for India, as numerous Mohammedans were invading the country. When Atisa, on his way to Tibet, got beyond the Nepal frontier, some Saivaites sent robbers to kill him. As soon as the robbers saw his face, they were struck dumb and motionless as statues. Atisa said, "I pity the robbers," and uttered some mantras and drew figures on the sand. The robbers were then restored to life. Further on, Atisa found some puppies dying on the roadside. He saved them, and their descendants are still to be seen at Rodeng in Nepal, a special breed. The following story is told of Atisa and one of his disciples. The disciple was starting on a journey, and with his alms-bag in his hand was bidding farewell to his master Atisa. Suddenly the disciple changed himself into a wolf, and devoured a corpse lying on the roadside. Then in a flash he turned himself into human shape again. Atisa said: "Now you can practise what form of worship you please." Atisa condemned the Tantric system for Buddhists, and once said "It is not good for a Buddhist priest to have learnt a Tantric charm from a heretic."

In Nayapala's reign an ominous event took place. The bazaars of Benares were looted in a raid by Nyaltogin, Mohammedan governor of Lahore.

Later on in the eleventh century there was a formidable revolt against the Pal dynasty by the Kaibarttas, or fishermen, led by Divvoka, who established himself as king

in Central Bengal. This revolt is surmised to have indicated an interesting tendency which undoubtedly developed during the eleventh century, a reaction towards Hinduism away from Buddhism. Buddhists forbade the taking of life, and the revolting fishermen could easily have come into violent conflict with the religious tenets of their rulers. Divvoka was succeeded by his son Bhima. The latter's name is still preserved in Central Bengal by a vast embankment, which traverses the district of Bogra from north to south, passing close to Mahasthan in the centre. From long exposure to sun, wind and rain this embankment has weathered to a hardness resembling stone, and forms a striking contrast to the soft alluvial plain on either side.

Bhima was defeated and killed by Rama pala, the grandson of Nayapala. Ramapala is the hero of the Sanskrit poem Rama Charitam.

A couplet in the Rama Charitam tells us that the art of Varendra has put into the shade the art of Southern India. Another interesting reference is to be found in a royal stone inscription of the first Sen king (the immediate successor of the Pal dynasty), disclosing the existence of a guild of artists in Varendra.

Ramapala raised a great statue, of Shiva, and statues of Skanda or Kantikeya, the god of war, and Ganesh, and a lofty temple to the eleven Rudras. All this may represent a concession to the rising tide of orthodox Brahminism, of which the Kaibartta revolt may have been a sign. But the fact that he remained a Buddhist is shown by the building of the great Vihara of Jaggaddala.

Ramapala attacked Utkala, and ruled the country up to Kalinga, and his armies conquered Kamrup.

Ramapala's principal minister was descended from the ministers of earlier Pal kings. The office seems to have been hereditary, as it is in Nepal to-day.

About the beginning of the twelfth century the Pal dynasty was finally overthrown, and was succeeded by the Senas.

This image of the Buddhist goddess Maha-Prati-sara, a protecting deity of Buddhism, comes from Dacca District. Its date may be assigned to the 11th century. The style of the art is riper and more florid than in the earlier examples, and signs are not wanting that the art has reached its full zenith and is about to enter on the downward path. But these figures of the late Pal age still preserve no little of the combined strength and grace which mark this great period of Indian art.

This is an image of the boar incarnation of Vishnu. There is a certain suggestion of Javanese sculpture in the lines of this figure.

This is a figure of Vishnu of the 11th century. The lions mastering the elephants will be noted at the sides of the deity. Though this work occurs late in the course of Pal art, it is a magnificent example of the art. The suggestion of Javanese sculpture already noted in the previous image occurs here with added force. There is, however, in this work still a tense and nervous vitality, a sense of mysterious significance, absent from the softer art of the south. Figures of Vishnu of earlier periods have already been shown. A glance at these figures will indicate more clearly than many words the course of Pal art.

Here we have the art in its primitive vigour.

This is the art in a more sophisticated and developed state, in the 10th century.

This figure of Vishnu of the 11th century represents the art in the stage of full development and approaching decline.

The overthrow of the Pal dynasty by the Sena dynasty in Bengal, at the end of the eleventh or beginning of the 12th century, implies very much more than a mere change of rulers. It marks the decline of Buddhism, and the establishment of a new caste system. We have seen that Ramapala, a Buddhist King, succeeded in crushing the Kaibartta revolt, which was probably anti-Buddhist, but he only did so with the help of allied feudatory chiefs, some of whom, and among them the Senas, were favourable to religious reform. That reform, like other so-called reforms in religion, was really a return to older gods. It was a reaction against the democratic and equalising tendencies of Buddhism, and a determination to uphold and multiply social and racial distinctions. The milder religion of Buddhism was left, and a return was made to the divinities of earlier ages. The religion of Buddha, which was born in India some sixteen centuries before, and which had endured longest in Bengal, had at last come to an end, and the age-long Hinduism, of which Buddhism itself was a branch and an aspect, revived in its ancient form, and Buddhism was no longer known in the land

of its birth. The exact means by which Brahminism supplanted Buddhism appear to have been the spread of Tantric doctrines. Common at first to both religions, they ultimately led to the extinction of Buddhism. At the present day the Buddhism of Darjeeling and other Himalayan countries adjoining Bengal is largely influenced by the Tantric system, and it is curious to note that nowadays in Nepal the Brahminical form of Hinduism is forcing the Buddhist religion northwards. It is also interesting to note that at the present day in India there are movements of reform and of revolt against the caste restrictions of orthodox Hinduism. In this respect these movements resemble Buddhism. One has only to mention the Brahmo Samaj in Bengal, the Arya Samaj in Northern India, and the agitation connected with the name of Gandhi (as regards the latter, in theory if not in practice) to realise the trend of modern tendencies in Hinduism.

The writer has no intention of criticising the revival of orthodox Brahminism, under the Sena dynasty, or of lamenting the decline of Buddhism. The narrower and harder form of religion was better suited to withstand the troublous times coming with the Mohammedan invasions. It is as though Hinduism instinctively collected its forces and braced itself to withstand the coming assault, a wonderful sign of the tremendous inherent vitality of this age-long system. So we find the Brahmins of the Sena age condemning the use of the vernacular language in religion, which the Buddhists had encouraged. "Who hears the eighteen Puranas or the Ramayana recited in Bengali will be thrown into the hell called Rourava." The Brahmin opposition was not mere jealous exclusion. There was a genuine fear that religious truths might be perverted or degraded and the ceremonies lose dignity by feeble or incorrect translations. In Sanskrit the ancient tradition was preserved inviolable.

The effect on art was adverse. As at this period in China and Japan, the Buddhistic system seemed to possess some affinity with the fine arts. The art of the orthodox Brahminical period succeeding the Buddhism of the Pal kings, shows distinct signs of degeneration. The art is harder, stiffer, more conventional, and with over-elaborated decoration. It is true that much of the art of the earlier period deals with deities of the orthodox Hindu pantheon. But the Buddhism which flourished side by side with it appears to have inspired its art. It is impossible to distinguish by the style of the art a Buddhistic from a Brahminical figure in Bengal, and the same is true of other parts of India. The transition in art from the Pal to the Sena period in Bengal in some ways resembles that from the Sung to the Ming period in China, Buddhism to Brahminism in the first instance, Buddhism to Confucianism in the second. The writer has no intention of suggesting that it was only under Buddhism that great art was produced in India, or that there is anything inimical in Brahminism to art. To take but one example, the great art of Rajput painting in Northern India from the sixteenth to the nineteenth centuries, is a complete contradiction to such an assertion. And indeed it could be disproved without difficulty in Bengal itself from works of art subsequent to the Mohammedan invasions. Buddhism has no monopoly of art in India, and when we consider that Buddhism is only an aspect of Hinduism, and originated from it, and, as far as India was concerned, was reabsorbed into it, this fact is not surprising. But it remains true, however, that in Bengal during the period with which we treat, with the decline of Buddhism art also declined.

Much might be said of the æsthetic theory of this art, how it is based on the Hindu doctrine of *Yoga*, the attempt to penetrate past Maya, the superficial illusion of the details of the outward form, to the essential reality of things. Bhava, the third of the ancient Hindu laws of the art of painting, and the characteristic principle of Indian æsthetic theory, which may be rendered as the influence of spirit on form, is concerned with this idea. It is interesting to note that the contemporary movement in art, sometimes known as Post-Impressionism, from Cézanne to such living artists as Matisse, and Picasso, frequently appears instinctively to incline in a similar direction—that is to say, that the artist devotes all his energy to an attempt to portray the essential character of his subject, to the neglect of its details and environment. The independence of design and its freedom from the trammels of mere representation and illusion, is another point of contact between these arts so widely separated in space and time. The large and increasing influence of the art of the East on contemporary art is an

interesting question, but one which belongs rather to a consideration of Oriental art in general than of the particular branch which we are considering to-day.

The art of the Pal empire has a certain transcendental character. The artists faithfully carried out the injunctions of the Shilpa Sastras, that it was their duty to portray gods, not men. Better the image of a *god*, however rudely and unskilfully wrought, than the most brilliant statue of a *man* that a human hand could execute.

The art of the Far East is still far better known in Europe than is the art of India. It is hoped that the few examples shown to-day of one school of Indian art may serve to explain and justify an expression used in the art and philosophy of the Far East itself—San Goku, "The Three Countries," China, Japan and India.

DISCUSSION.

THE CHAIRMAN (Lord Ronaldshay) said Mr. French had given a most interesting account of the art of what must undoubtedly be described as one of the most important eras in the history of Bengal, for recent research had certainly made it clear that under the Pal kings Buddhism enjoyed a period of cultural splendour prior to its decay and its eventual disappearance from the land of its birth. Incidentally the lecturer had touched upon the ancient Hindu theory of the origin of kingship—a theory which bore a most striking resemblance to the theory known as the "social contract," which one was accustomed to think of in connexion with the names of men like Hobbes and other European thinkers of the 17th century A.D. He had told, for example, how the founder of the Pal dynasty was made king by the people, in order to bring to an end a period of anarchy, a state of affairs which, as Mr. French had said, was described by the people of those days as Mâtsya-nyâya, a word which he had translated as "fishy." A most interesting reference to the practice of electing a king to purge society of the crimes which overtook it appeared in a very ancient work on political science, the manuscript of which was found by an Indian scholar in the South of India in the early years of the present century. That work, by Kantilya, the Prime Minister of Chandragupta, the famous founder of the Mauryan Empire, which must have been founded, he supposed, about 300 years B.C. contained the following passage:—

> "People afflicted with anarchy consequent on the Mâtsya-nyâya,—the practice of the bigger fish swallowing the smaller—first elected Manu, son of Vivasvat, to be their king."

And then followed the terms of the contract which was made between the people and the person whom they selected to rule over them. "They allotted one-sixth of their grains and one-tenth of their merchandise as his share. Subsisting on this wage, kings became capable of giving safety and security to their subjects and removing their sins." Here, then, they had a perfectly plain statement as to the origin of kingship made some centuries before Christ; and Mr. French had quoted from a manuscript some thousand or more years later a passage showing that not only was that theory recognised in those days as an adequate explanation of the origin of kingship, but was actually put into practice in the times of which Mr. French had been speaking.

Turning to the art of the period, it would be agreed, he thought, that with the aid of his illustrations Mr. French had been able to give some idea of its quality, and they might well agree with him as to the interesting and valuable results which would be likely to accrue if systematic excavation on a generous scale was undertaken in Northern Bengal; for it was unquestionably the case that under the Pal dynasty, whose sway extended over the greater part of Northern Bengal, amongst other parts, there was a great flowering of Buddhist art, so much so that it had been claimed that "from the 9th to the 12th century the whole of the Buddhist world drew its inspiration in literature and art from the Kingdom of Gauda." For some years past exploration on a modest scale had been carried out, as Mr. French had said, by a body of men known as the Varendra Research Society. That society was founded by an Indian gentleman, Kumar Sarat Kumar-Roy, of Dighapatiya, and consisted of a number of Indian scholars and others interested in the work of research, who had already done valuable antiquarian work, and by their labours had thrown much light upon the history of the Pal Empire. Nearly five years ago he (the Chairman) had been privileged to open a museum at the little town of Rajshahi, in Northern Bengal, which formed the centre of the activities of the society—a museum which now housed some hundreds of pieces of stone sculpture, together with a collection of metal images, ancient copperplates and coins, as well as a fine assortment of Sanscrit manuscripts. Amongst the sculpture he recalled some beautiful images of Chandi and Vishnu similar to those shown in Mr. French's photographs. He was particularly glad of that opportunity of bearing witness to the high spirit of scholarship and research by which the members of the Varendra Society were actuated, all the more so because it was impossible not to notice in India at the present day a certain tendency to draw somewhat fanciful pictures of a resplendent past rather than to reconstruct a picture of actualities based upon critical investigation. Solid work such as that which was now being done by the Varendra Research Society certainly redounded to the credit of Indian scholarship, and called forth the gratitude of scholars, and particularly of historians, all the world over.

Mr. French's paper was so suggestive and so full of interest from such various points of view that it would certainly be easy to comment upon it at great length, but there were present that afternoon persons who were much better qualified

than he to speak upon the art of the Pal period; and since the meeting was fortunate enough to have present an admirable representative from the British Museum, Mr. Laurence Binyon, he would ask him whether he would say a few words.

MR. LAURENCE BINYON, LL.D., said it was very kind of Lord Ronaldshay to refer to him as if he were an authority, but he had rarely felt more ignorant than he had that afternoon in listening to Mr. French's paper. He was, however, very glad to have the opportunity of expressing gratitude to Mr. French not merely speaking for himself, but as one of a number of English students of Indian art who had not the opportunity to visit India themselves, and who were enormously indebted to sympathetic students like Mr. French for all the pains and research they were at to bring before them such beautiful objects as he had shown. He thought the qualities emphasised in the paper were just those they really had, majesty and grace, and in particular a mysterious power as of aboriginal, interior life. It was very interesting to remember that the Pal dynasty was in great part contemporary with the splendid T'ang dynasty in China, the greatest period of Chinese creative art. It was known that during that time there was living intercourse between the two countries; there were hundreds of Indian Buddhist monks in Lo Yang, the capital of China, and some of these very images might have had a direct influence on the grand Buddhist art of T'ang.

There were two points in the paper which particularly struck him. One was Mr. French's reference to Egypt and to the large sums and elaborate research devoted to Egyptian exploration, compared with the little that was done for the exploration of Indian art. However, it must be realised that it took a long time for a new art to get the necessary prestige for it to be adequately studied. What was a mere curiosity to one generation was accepted by the next as something worthy of universal study. He might mention that in the British Museum during part of the 19th century there existed what was called a Department of Oriental Antiquities. That Department no longer existed. One would have thought that oriental antiquities would have included something of the art of India, Persia, China and Japan: but there was not a single object from beyond the Euphrates. Oriental antiquities in the middle of the 19th century meant Assyria and Egypt, and that might suggest how far progress had been made in the last half century in the widening of our knowledge of and sympathies with the art of the world, and especially of the great art of Asia. While speaking of excavation and exploration he would like to express the hope that not only would money be found for increasing that work in India, but that also before very long we might have in London some representative series of good casts from the chief masterpieces of Indian sculpture. At present the Indian section at South Kensington was most inadequately housed, and very crowded, and a new building really was required. He did not think one wanted to have a great mass, but a choice selection of the most impressive, really "world-masterpieces" of Indian sculpture would be a very great boon to students, and make a great impression on the general public.

The other point that struck him was Mr. French's reference to what was called the advanced movement in art of to-day. A great many people, most people probably, found the works of those painters and sculptors antipathetic altogether; but whatever was thought about them—and he thought their efforts had not been particularly successful hitherto—it was not a question of a mere change of fashion in art. The movement of the last generation in painting was impressionism, and the chief apostle of impressionism, R. A. M. Stevenson, said the first business of the painter was to forget the fact that things existed; he was simply to regard the impression on his eye of the colours and tones, quite regardless of what they were in themselves and their essential character. The new movement was an absolute recoil from that attitude, and it was not only a question of art; he thought it had its roots in an instinctive dissatisfaction with our civilisation,—not only with our art,—which had been too much absorbed in the surface of life, and too little concerned with essentials.

MR. A. YUSUF ALI, C.B.E., I.C.S., retired, said that in common with the rest of the audience he would like to say how much he enjoyed the very clear exposition of Pal art given by Mr. French. It was not a subject which had been often treated. In old-fashioned works like, say, Stewart's "History of Bengal," the cultural side of Bengal had been altogether neglected; in fact Stewart dealt almost exclusively with the political history from the invasion of the Muslims to the British conquest. The new fashion of bringing back history to its bearings, trying to make all the information we get from sculpture, from architecture, from paintings, mural or otherwise, bear on the life of the people and the interpretation of the political history, was one of the most welcome features of historical work at the present time. And it was of peculiar value in the case of India. When he was a child at school the history of India presented to him was a lifeless and chaotic jumble. He could not string it together, and he remembered once making a very crude remark, which he thought was justified by later experience. He was asked by a distinguished visitor to his college which history he liked best. He was expected to answer, "The history of India." He answered, instead, "The history of England." He was not unpatriotic; what he meant was that the history of England, as taught to him, presented a continuous growth, a movement amongst the people. He could see how the people began from their root beginnings; how they sculptured, as it were, their political history; how the religious reformation came and joined on with the various social and intellectual movements; how Puritanism itself led to the Stuart reaction, and how a number of such facts grouped themselves in vital relations until he could form an

intelligent picture. In the history of India in those days there was practically a complete gap between the Vedas and Buddhism to the Mohammedan invasion; and although he was naturally proud of the achievements of his own people in India, he felt that it was a gap that ought to be filled. There was probably very little material in those days. Now it was accumulating, and the period of the Guptas, for instance, stood out clearly before them if they utilised the vast material that was at their disposal. For that reason he thought it would be an excellent thing if the suggestion thrown out by so great an authority as Mr. Laurence Binyon were followed up, and if they had in India—he would prefer it in Delhi, but the precise locus was of little importance—in Calcutta or Delhi or even in London, a good résumé, not of the old sort, but of the kind which brings together the cultural forces and shows the continuous development of Indian art and culture from Buddhistic and Mauryan times through the Gupta ages down to the present day. He felt that the history of India could only be understood in that way; and Mr. French's paper was an illustration in point.

The Pal period was considered a local period, but Mr. French had shown how a local period could be studied so that it could be made to fit into the general history of India; and it was only by the study of local periods that one could obtain that grasp over general history which made things clear. He was not at present quite sure whether Mr. French realised the relation between the art which he had so admirably described and Gupta art. He (the speaker) had been a very close student of Gupta art, which had a very wide geographical range. But its range in chronology seemed equally wide. The art of the age of Harsha Vardhana, whose capital was at Kanauj, in the middle of the United Provinces, was practically Gupta art. For centuries after Harsha the same traditions continued. Many examples were to be found in the United Provinces. He could not help feeling that the first beautiful example of the goddess Chandi which Mr. French threw on the screen, and which he had referred to as in some way connected with Gupta art, clearly showed the affinities of Pal art to Gupta art. He thought the perfect naturalness, the directness, the vigour of execution, were signs of an imperial spirit that knew its own mind. The attempt on the part of the sculptor to portray the benevolent features of a goddess who, at an early stage in the hitsory of India, was a very bloodthirsty goddess—witness the references to her in a play like "The Little Clay Cart" (Mrichchha Katika),—was evidence of a refinement characteristic of the Gupta tradition; and as that tradition became remote one found also that there was a debasement, a deterioration, a progress downward (if he might use an Irishism). Nothing illustrated that better than the florid examples that were thrown on the screen later. Possibly they were better in technique; certainly, to his mind, they were very much inferior in the sincerity, vigour and directness connected with all the best art.

He had no time to elaborate the theme, but he would like to end with a very brief examination of a fascinating question. In Indian art, the art inspired by Buddhism held a pre-eminent place. What was it that gave this art such a great hold over our minds compared with some of the later debased art? He did not mean to exclude Brahmanical art; he considered that the best examples of Gupta or Pala art pre-supposed Buddhist art; where Shiva or Vishnu was introduced his personality was regarded as a Buddhist would regard the personality of Buddha. It seemed to him that the Buddhist religion was specially characterised and distinguished in India from the numerous cults in the comprehensive system of Hinduism by three acts, first, that it was simple; secondly, that it appealed to the people and not to a coterie; and thirdly, that it went directly to the very deepest feelings of humanity instead of standing on a transcendent metaphysical tradition. Those characteristics in all ages were sure to give to art a pre-eminence which a merely æsthetic art could not attain. That was found in the Græco-Buddhist or Gandhava art of the best period. It was found in the Gupta art of the best period; and he was extremely glad to note the same characteristic in the early Pal art, which was Buddhist. If one took some examples of statuary which had been recently discovered in the United Provinces, they also illustrated his point. He did not know whether there was anyone in the audience who had seen that beautiful statue of Vishnu which was recently discovered in Gorakhpur, and for which a special temple was going to be built, in order that it might be fitly housed. It was of black polished marble, like the one which Mr. French had shown, and possibly it dated from either the same period or a little earlier, nearer the Gupta period. But there again, one found that although it was a statue of a Brahmanical god, it was treated with all the affection of a Mahayana Buddhist for a personal deity; it was treated with something of the familiarity with which popular religion clothed its gods and goddesses; and until one got to that sincerity, that directness, that familiarity, that desire to bring art into relation with our own lives,—until then, art must necessarily be the art of a coterie, and not a popular art. For this reason, if he were addressing an audience of his own countrymen, he would specially insist, particularly in the new art which they are building up now, and which he hoped would be a sign and symbol of that great and vigorous nationality to which India was looking forward, that in that art they must try and study the facts of present life, and apply all the technical knowledge and skill they could attain in order to interpret it, and not merely be lost in the mazes of a more or less vague or elusive tradition.

He had much pleasure in bearing his testimony to the value of Mr. French's paper, and perhaps it would also be permissible to hope that a similar attempt would be made to interpret Gupta art, for which, perhaps, the material was even more abundant than for Pal art.

Mr. A. L. Saunders, C.S.I., formerly Commissioner of Lucknow, said the only qualification he could possibly have for taking part in the discussion was his somewhat long service in an adjoining province, where artistic problems presented themselves from a somewhat different angle, which had been far better explained than he could hope to do by his colleague, Mr. Yusuf Ali. He would also like to express his agreement with Mr. Yusuf Ali when he referred to the great interest which the artistic history either of the Pal dynasty or any other period had in its bearings on the general and religious history of the same period. One so often got histories on one line alone, and the connexion between the two was not always brought out. That was particularly so with regard to the rise and fall of the Buddhist civilisation in India. One knew about the rise of that wonderful civilisation, and how it not only introduced new ideas but actually spread over the whole of Asia, even to the extent of exerting an influence over the Roman civilisation in Asia. What was involved in a haze of doubt and difficulty was why the civilisation having attained that point should have fallen and disappeared. Whether it was due to the Mohammedan invasion, or whether the Mohammedan invasion in turn was invited by the weakness of India it was not for him to say. There was, of course, the comparison with the decline of the Roman civilisation; but there it was more easily explained because of the altering of the balance of the population. The invaders of the Roman Empire were enormously superior in numbers to those of its inhabitants, but in the case of the Hindu civilisation it was different. It was perhaps a natural phenomenon; the rise, the decline, and the fall of a great civilisation. Mr. French had shown by reference to actual statues how the mentality of that civilisation might have varied in accordance with its art, and that was one of the most interesting of his explanations.

Sir Charles S. Bayley, G.C.I.E., K.C.S.I., said that after the remarks of Lord Ronaldshay, and the other exceedingly interesting speeches to which they had listened, it would be almost wicked to interpose any remarks of his own; but he wished to express, on behalf of the Royal Society of Arts—he happened to be the Chairman of the Indian Section for the moment—and on behalf of the audience generally, their gratitude to Mr. French. It was obvious how greatly the paper had been appreciated by what might be called the more instructed part of the audience; but he (Sir Charles Bayley) wanted to speak on behalf of another section of the audience, namely, those who, although they had been in India for some time, were discreditably ignorant of Indian art, and had not the knowledge of Indian history which they would like to have. He was one of those, and if there were any others in his position he was sure they would feel as grateful to Mr. French as he did himself for what Mr. French had taught them. His address had been most valuable, and the value of it had already received the highest testimony that afternoon. He was sure that he was expressing the wish of the whole audience when he proposed a hearty vote of thanks to the author and to Lord Ronaldshay for taking the chair. No one could help realising what attention Lord Ronaldshay must have given during his Governorship, and probably at other times, to Indian affairs and to Indian art and Indian feeling. It was only necessary to have been present at the lecture which he gave the Society on "A Clash of Ideals as a Source of Indian Unrest" at the beginning of the previous year, to understand that very fully.

OBITUARY.

Sir George T. Beilby.

Sir George T. Beilby, F.R.S., LL.D., died on 31st July. By his death the Royal Society of Arts lost a member whose scientific work and industrial activities formed eminent contributions to the objects for which the Society exists, and whose devoted public service has been most fruitful in the local and national machinery for research and education in science and technology.

Sir George became a member of the Society in 1884 and as long ago as that year he read before its old "Applied Chemistry and Physics Section" a notable paper on "The Production of Ammonia from the Nitrogen of Minerals." On that occasion the late Sir William H. Perkin was in the chair—truly a notable conjunction of chemists who have broken new ground in the advance of chemical industries. In 1881 Sir George Beilby and his colleague Dr. James Young patented a retort which so greatly improved the appliances at the disposal of the Mineral Oil industry that its output of useful products steadily increased and it became one of the most flourishing of the industries of Central Scotland. Ten years later—to refer only to one of his major contributions to chemical industry—he introduced a method of producing cyanide, which in the hands of the Cassel Cyanide Company at Maryhill, Glasgow, increased immensely the production of the material essential for the recovery of gold by the cyanide process first practiced in New Zealand in 1889. His services in the promotion of Chemical Industries were no less productive in other departments for which he worked as Scientific Director of Chemical Works in this country and overseas.

He devoted much attention to problems bearing on fuel economy and smoke prevention in connexion with the coal consumption of Great Britain. He reported on this to the Royal Commission on Coal Supplies in 1903. In 1917 he was appointed Director of Fuel Research under the Department of Scientific and Industrial Research which had been established in 1916, Sir George Beilby being a member of the Advisory Council of the new department. From 1917 onwards, he made service in this outstanding public interest the first charge on his energies. Under his personal guidance and control a central Fuel Research station

was erected at Greenwich by the Government. The series of important researches which have since been conducted there and in related laboratories, now constitute a body of ascertained facts and of proved methods of investigation which forms for further research a solid foundation and a system of well blazed tracks in the main directions of enquiry. Sir George Beilby's services to the country and to science in this matter extended over six years and they were entirely voluntary. In this respect they were on the same basis as those he gave to the Naval and Military Authorities during the war. He accepted no payment for services and he presented to the Government the rights in every patent he took out. A member of the Central Committee of the Admiralty Board of Inventions and Research and of the Trench and Chemical Warfare Research Committees he had been rendering continuous service to the prosecution of the war; the great value of his knowledge, skill and assiduity in these connexions is known only to those who had the good fortune to be associated with him in the team work of that period. Beilby's experience, judgment and resource were at the disposal of every colleague and his personality counted for a great deal in the grapple with difficulties, whether in matters of pure science or in the special field of developing from the results of scientific investigation practicable methods of production on the great scale required.

The last nine years of his life were indeed devoted gratuitously to national work in London, although for part of that time he was nominally resident in Glasgow. Before the War work which kept him so continuously in London, he had been an active citizen of the city which was the centre of his industrial activities. In particular he laboured for the great institution which is now the Royal Technical College. He was elected Chairman of the Governors of the College in 1907, and he spared no pains to secure for the College the co-operation of public authorities and institutions in Glasgow and the West of Scotland. His familiar acquaintance with the links between science, industry and commerce, and his fine personality were cogent aids in the steady advancement of the College as a centre of teaching and research.

Sir George Beilby received a knighthood in 1916. He was elected a fellow of the Royal Society in 1906. He was for several years a member of the Council of the Royal Society of Arts and he contributed £500 to the Society's Building Fund.

F.G.O.

CONFERENCE AT WEMBLEY ON ILLUMINATING ENGINEERING.

On August 12th, the Illuminating Engineering Society held a Conference at Wembley to discuss "The Best Means of Promoting Public Appreciation of the Benefits of Good Lighting." The subject was introduced by Mr. Leon Gaster, who has ecently returned from Geneva, where he attended the International Conference on Industrial Hygiene, which took place under the auspices of the University of Geneva, and the International Illumination Commission Conference. A brief account was given of the work done at the above named Conferences and by the Illuminating Engineering Society. since its inception in this country, and by other illuminating engineering societies, In view of the large experience and information obtained during the last 18 years, it was felt that the time is now ripe to bring to the notice of the general public the advantages to be derived from good lighting, and the drawbacks of badly lighted factories, schools, etc. The conference was very well attended and fully representative. After an interesting discussion the following two resolutions were passed:

(1) "That, as a result of 18 years of experience of Illuminating Engineering in this country and the United States, this Conference considers that the time is ripe for a comprehensive effort to promote public appreciation of the benefits of good lighting, and views with approval the desire of the Illuminating Engineering Society to prepare a suitable scheme for this purpose, with the co-operation of other bodies interested in various aspects of illumination."

(2) "The Conference recommends that every support should be given by institutions for the encouragement of reasearch, members of the public and by all sections of the lighting industry to the Illuminating Engineering Society in carrying out such a scheme."

The following papers were read and discussed at the Conference:—"The Illumination of Highways from the Motorists' point of view," by Mr. Edward H. Fryer (Head of the Road Dept., Automobile Association); "Some Notes on the Electric Lighting of the British Empire Exhibition," by Mr. Haydn T. Harrison; and "Some Notes on the Gas Lighting at the British Empire Exhibition," by Mr. G. L. Jennings (Brentford Gas Company).

LIVESTOCK INDUSTRY OF NORTHERN MANCHURIA.

A very small portion of the total resources of the livestock industry of northern Manchuria is being utilised at the present time. This is partly due to the fact that the important markets of Siberia are practically closed to trade. More than 50 per cent. of the meat trade of northern Manchuria is in the hands of a British firm, which maintains a modern packing plant at Harbin.

From a report by the United States Consul at Harbin it appears that the Kinghan Mountains form the border line between the barn-fed cattle industry and nomadic steppe herding. The entire territory from Tsitsikar to Harbin and Kwangchentze, on both sides of the Chinese Eastern Railway line, represents regions of farms with well-developed cereal culture and important trading centres. However, colonisation has not penetrated

east of the Kinghan Mountains into what is known as the steppe country, with its enormous width and sparse population of nomadic tribes.

The principal centres for the trade in cattle are Hailar and Manchuria, although the place of the latter point is more and more being taken by Chalainor, which is only 19 miles distant and escapes the almost prohibitive taxes imposed in China. At these two points all of the more important cattle dealers maintain agents or branch offices. In the early spring these agents are supplied with silver cash, and they proceed into the plains country, where they close bargains directly with the owners of herds. By the middle of summer these cattle are driven to stations of the Chinese Eastern Railway and left to graze until the winter killing at local slaughterhouses. The carcasses are then shipped to the different markets or resold to merchants from the Maritime Province, Pri-Amur district, or Harbin. A total of 45,863 head was slaughtered during 1922 in northern Manchuria. However, this is small in comparison with the former times, during the imperial régime, when in Hailar alone 25,000 head were slaughtered annually, as against 4,000 at the present time. The best meat cattle come from the district south of Hailar, on the plains watered by the Kurlyn River. This region could easily supply 30,000 head of horned cattle and 500,000 sheep. During 1922 104,897 sheep were slaughtered in northern Manchuria, distributed as follows: 50,149 at Hailar, 24,324 at Manchuria, 1,247 at Tsitsikar, and 3,962 in other districts. During 1923 at Hailar alone 150,000 sheep were bought.

Hog raising takes first place among the industries of the densely populated districts of northern Manchuria. With the low price of cereals, hog raising has been found by the local Chinese and Russian farmers to be a profitable enterprise, and its development has kept step with the colonisation of the country. Therefore, the districts along the southern line of the Chinese Eastern Railway and the districts surrounding the city of Harbin are the centres of the industry. According to the economic bureau of the Chinese Eastern Railway, there are approximately 3,200,000 hogs in the Anda, Harbin, and southern districts.

The breeding of domestic pigs was begun very early in China (more than 3,000 years B.C.), but in spite of this and the fact that the industry has grown enormously, but little attention is paid to the improvement of breeds. However, the Chinese hog is remarkable for its fertility and early maturity. The methods of caring for and of fattening the hogs are very primitive, as is the mode of slaughtering, a large part of which is done on the farms.

The organisation of the hog buying is almost entirely in the hands of the Chinese merchants, who through their agents close bargains with the farmers and bring the animals to market. No reliable data are obtainable as to the number of hogs slaughtered, inasmuch as the majority of them are home killed, and are prepared on the farms. Public slaughter-houses kill on an average 900,000 animals yearly.

ELECTRIC POWER SCHEME IN MOROCCO.

In his annual report on the economic and commercial conditions in the French zone of Morocco, H.M. Consul at Casablanca states that during the past year a big "centrale thermique" has been and still is in course of construction just outside Casablanca. The owners, the Compagnie des Chemins de Fer du Maroc, are furnishing this power station with three turbo-alternators of 6,000 k.w. each or 18,000 kilowatts in all, with a 60,000-volts tension.

A general concession for the organisation of the production, transport and distribution of electrical energy in Morocco, granted under a law dated July 18th, 1923, is of "national" importance for Morocco and incidentally it embraces the Central Thermique of Casablanca mentioned above. A few details must suffice to indicate its great scope:

The concession is granted to the Banque de Paris et des Pays-Bas (acting in its own name and in the name of some twenty-four great French banking, electrical, railway and other enterprises) until the end of this century.

Its main objective as defined above is to be attained through:—

(*a*) The Casablanca Central Thermique.

(*b*) A first hydro-electric power station on the Oum-er-Rebia river, provision being made for a minimum of 5,000 kilowatts.

(*c*) A second hydraulic station, or a group of stations, to be constructed at some point or points to be determined in the upper basin of the Oum-er-Rebia

(*d*) Electric current for the electrification of (i) the Sidi-el-Aidi-Kouriga (Oued-Zem) to Casablanca phosphate railway; (ii) electrification of the broad gauge Rabat-Casablanca railway (now under construction) and the electricity needs of Rabat and Kenitra.

(*e*) (i) A transport line of electrical energy, in form of the letter Y, to join the Sidi Machou and Casablanca stations with a branch through Azemmour to Mazagan; (ii) the same between Sidi Machou and Sidi-el-Aidi.

(*f*) A line of current to electrify th railway between Sidi-el-Aidi and Marrakesh, and supply electricity to Settat and Marrakesh.

(*g*) Lines between the power station on the upper and lower Oum-er-Rebia river

(*h*) Any further secondary lines found to be necessary.

Part of this programme has no date fixed for completion, but the Casablanca power station was to be completed by July 1st, 1924, and the Sidi Machou station by the end of 1927.

The concession is criticised as providing for needs not likely to become pressing for the inhabitants for many years; on the other hand it is argued that, in the absence of coal and petrol, Morocco must be provided with a local source of power always to hand and procurable at a price fixed by herself. The subsequent development of

the country will prove which of these two schools of thought is correct.

Small electric stations are being erected in certain of the towns, and Mazagan and Saffi already and Marrakesh this year will be provided with power sufficient for all lighting and moderate industrial needs.

MINERAL WEALTH OF THE FRENCH ZONE OF MOROCCO.

So far as is known at present, writes H.M. Consul at Casablanca, the great subsoil wealth of Morocco lies in its limitless phosphate beds. The only group of beds at present exploited stretch over an area of 80 by 50 kilometres around El Bouroudj, and the product is now averaging 74.80 per cent. phosphate of lime. The output from nil, in 1920, rose to 190,000 tons in 1923, and the estimate for 1924 is 350,000 tons, with an annual growth of 150,000 tons for some years to come. A broad gauge railway now joins the chief extraction centre to the quays of Casablanca, where the phosphates can be loaded by special machinery at the rate of 300 tons per hour.

As regards secondary minerals, the principal deposits so far located are :—

(i) Manganese—South of Oudjda.
(ii) Manganese and lead—North-west of Figuig.
(iii) Tin—Oulmes district.
(iv) Iron—Camp Boulhaut and Sokhrat-el-Djaja.
(v) Gold and silver—Moulay-bou-Azza.
(vi) Lead—The Rehamna.
(vii) Lead and copper—the Zaer region.

Further small quantities of iron have been traced in the Djebel Haddid and of copper to the south of Marrakesh, where incidentally a gold mine is being exploited. As regards fuel, only insignificant traces of coal have been found hitherto, while borings for petroleum, which have been carried out fairly extensively, have given unsatisfactory results, though hope of remunerative discoveries is not yet abandoned.

THE CITRIC ACID INDUSTRY OF ITALY.

The Italian citric acid industry during recent years has developed to considerable proportions. Italy, more especially Sicily, has always had practically a world monopoly in connexion with the production of calcium citrate. From 1908 to 1910 the annual Italian output amounted to about 6,000 metric tons. From 1918 to 1920 it rose approximately to 8,500 tons. It is estimated that during the last few years production has approximated 8,000 tons yearly. Although other countries, namely the Dominican Republic, Spain, and the British West Indies, as well as California, are producing fair quantities of calcium citrate, the Sicilian industry continues to account for nine tenths of the world output.

From a report by the United States Trade Commissioner at Rome, it appears that the first plant which made a real success in producing citric acid in Sicily was the Fabbrica Chimica Arenella, a subsidiary of the Societé Anonima Chimica Italiana Godemberg, in turn an affiliation of the Chemische Fabrik Godemberg of Wiesbaden (Germany). The German company sent 15 of its best workers to the plant at Palermo and gradually obtained good results. In the year 1913-14 a production of about 1,000 tons of citric acid was reached. In 1916 the Fabbrica Chimica Arenella was freed from its foreign connexions and is to-day the largest citric acid producer in the world. The number of workers employed is about 450, and it has a capacity of from 2,500 to 3,000 tons per annum of calcium citrate—about one-third of the entire production of Sicily—from which 1,500 to 2,000 tons of citric acid are obtained. Besides this company two others have been organised in recent years and another is at present under construction. All three are located in the Province of Messina and are able to transform 5,500 tons of calcium citrate per annum.

If to these 5,500 tons be added the 2,500 tons output of the Arenella Co., a total of 8,000 metric tons, approximating Sicily's total annual production of calcium citrate, is obtained. This industry has come to the front in the course of a very few years and has had a growth which might, perhaps, even be considered too rapid.

Besides the Sicilian industry there is also the Societé Anonima L'Appula, which has plants in Italy proper, at Vercelli and Linate, whose combined output of citric acid for the year 1922 reached 447 metric tons. These two plants, however, are capable of producing as much as 1,200 tons per annum.

RESOURCES OF THE SPANISH ZONE OF MOROCCO.

In reporting on the trade and commerce of the Spanish Zone of Morocco, Mr. C. A. Were, late H.M. Vice-Consul at Tetuan, writes that the trade and commerce of the country are still in a very undeveloped and unsatisfactory state. It is true that its possibilities are at best restricted, but little or nothing has been done to develop available resources, while in some instances existing industries have fallen off in production or even ceased to exist. There are, indeed, no organised industries in existence at present, and when it is added that the agricultural produce of the country is for the moment insufficient for its own needs, and that its potential mineral wealth has been exploited only on a small scale, it will be readily understood that its exports are insignificant.

Agriculture.—The zone is never likely to become more than self-supporting in this respect, owing to the unsuitable nature of the greater part of its soil and the abundance of palmetto, the extirpation of which is an exceedingly tedious and costly business. Exceptions are the plain of Rio Martin

and, in particular, the territory of the Khlot, near Alcazar, where exceedingly fine crops of cereals are produced.

Stock-breeding.—The breeding of stock should, if systematically organised and directed, be of great value to the zone. Most of the land, unsuitable for various reasons for agricultural purposes, provides excellent grazing. Even at the present time the cattle, sheep, pigs, etc., to be seen in the zone are remarkably healthy, though on the small side. The state of insecurity still prevailing in many districts, however, is a serious obstacle, and it is only in the vicinity of the towns that cattle can be pastured without fear of robbery.

Minerals.—Great hopes of the presence in the Riff and elsewhere of large and commercially workable mineral deposits have for long been entertained, and the Department of Overseas Trade is in possession of a list, compiled by the late Mr. Vice-Consul Atkinson from native sources of information, of such deposits, with their approximate situation as described to him. There is every reason to suppose that the information contained therein is ampler and more correct than that gathered by the various mining engineers and prospectors who have ventured into the Riff. Owing to the permanent unrest prevailing in that country it is only by favour of the Riffian leader that the supposed mineral deposits can be visited, and he is chary of granting permission, being distrustful of Europeans in general, and anxious to obtain substantial pecuniary remuneration before permitting even investigation. It appears, therefore, that the investigation (leaving out of account the exploitation) of the mineral resources of the Riff must be postponed either until the Riffian chieftain has acquired a greater insight into European methods of business, or until the protecting power has entirely subjugated the district. Either process will absorb much time. Apart from the Riff deposits, two iron-ore mines are being worked, with fair success, in the Melilla district, by Spanish companies, and a Spanish company has made various attempts to extract tin and other minerals in the vicinty of Tetuan, with meagre results.

HARBOUR WORKS IN MOROCCO.

The port of Casablanca has been the greatest public work carried out by the French in Morocco. The port commenced in 1913, by the firm of Schneider et Cie, is now approaching completion in its most arduous part. The massive grand jetty, which is to extend for 2,050 metres, is nearly finished, while the Transversal jetty has advanced over 860 metres out of the 1,600 metres of its projected length. Already the 150 acres of water space are fully protected in all weathers. Two to three steamers can now lie alongside the grand jetty simultaneously and passengers be landed direct on to the quay.

According to the survey of economic and commercial conditions in the French zone of Morocco by H.M. Consul at Casablanca, supplementary docks and wharves are to be built later, and the equipment will be sufficient to handle 1,500,000 tons of merchandise per annum, exclusive of phosphates. The 1923 figures, including phosphates (190,000 tons), gave a total of 680,000 tons handled in the port.

The port of Saffi—for lighters—was commenced in 1923, and work is proceeding actively on the port at the mouth of the Bou Regreg—the port of Rabat-Sallee.

At Fedhala, where a small lighter port has been constructed, there is a scheme to continue construction and equip the harbour as the oil fuel port of Morocco, and it is believed the necessary steps will be taken shortly.

Work is also proceeding in the small Mazagan port. Finally Agadir, the southernmost port of Morocco, is being equipped with a lighterage harbour.

The opening of Agadir to commerce will, it is feared, affect the prosperity of Mogador, as the Sous or district south of the Atlas is at present supplied through Mogador.

The policy of spending so much money (including Mehedia-Kenitra in the north) on a row of seven small Atlantic ports, in addition to the immense work undertaken at Casablanca, is declared in many quarters to be unnecessary and extravagant, in view of the modest maximum yield that Morocco can render for many years to come.

GENERAL NOTE.

INSTITUTE OF METALS.—The Autumn Meeting of the Institute of Metals will be held in London from September 8th to 11th. The third annual Autumn Lecture will be delivered on the former day by Mr. W. M. Corse, S.B., of the National Research Council, Washington, U.S.A., the subject being "Recent Developments in Non-Ferrous Metallurgy in the United States, with Special Reference to Nickel and Aluminium-Bronze." Amongst the communications expected to be submitted are the following:—"A Method for Measuring Internal Stress in Brass Tubes," by Robert J. Anderson, B.S. (Boston, Mass., U.S.A.) and Everett G. Fahlman, B.S. (Cleveland, O., U.S.A.); "Seventh Report to the Corrosion Research Committee of the Institute of Metals," by Guy D. Bengough, M.A., D.Sc. and R. May, A.R.S.M. (London); "Investigation of the Effects of Impurities on Copper. Part II.—The Effect of Iron on Copper," by D. Hanson, D.Sc. and Grace W. Ford, B.Sc. (Teddington); "Experiments on the Working of Nickel for Coinage," by Sir Thomas K. Rose, D.Sc., A.R.S.M., and J. H. Watson, M.C., B.Sc., A.R.S.M. (London); "Studies in the Aluminium-Zinc System," by Tomojiro Tanabe (Osaka, Japan); and "Metal Spraying and Sprayed Metal," by T. Henry Turner, M.Sc., and W. E. Ballard (Birmingham).

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.2.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

THURSDAY, JULY 24TH, 1924.

THE HON. W. G. A. ORMSBY-GORE, M.P., late Under-Secretary of State for the Colonies, in the chair.

THE CHAIRMAN said the Royal Society of Arts and the audience were deeply indebted to M. Franck for attending that afternoon to deliver a lecture on "Recent Developments in the Belgian Congo," and his ideas of the future of that territory. It was a matter of great interest to a British audience. M. Franck was Belgian Minister of the Colonies from 1918 to 1924. Before 1918, he had languished for a certain time in a German prison for patriotically maintaining the rights of his fellow-countrymen, for which he had our double regard as an Ally. Not only had M. Franck been Minister of the Colonies in his own country, but he had twice visited the Congo, on one occasion going through to the East Coast of Africa.

He (the Chairman) was personally interested in the subject of the lecture, as the British Government was sending him out shortly as Chairman of a Commission to the Tanganyika Territory, Uganda, and the other British Dependencies in East Africa. The great problems of transportation, public health and increased production which M. Franck and his country had before them were in a way peculiarly their own, and included the development of what was probably the largest and most valuable copper-field in the world, Katanga, which, now in its infancy, was destined to play a big part in the future of Tropical Africa as a whole.

The paper read was:—

RECENT DEVELOPMENTS IN THE BELGIAN CONGO.

By LOUIS FRANCK, G.C.V.O.

(Late Colonial Minister of Belgium.)

What are the problems of the Congo? They may be summarised in two words: transportation and population.

By its very nature, Central Africa, which is a sort of enormous flat cup rising high above the sea-level, has a splendid system of waterways. But this system has a great drawback; it is cut off from the seas and barred in various places by falls and rapids.

Only the modern mechanical means of carriage can supplement this deficiency of nature.

After travelling all over the country, Stanley put the matter in a nutshell:—"Without railways, the Congo is not worth a shilling." But even an adequate system of conveyance and carriage will not develop the enormous country without a numerous, healthy and efficient population.

PROBLEMS OF TRANSPORT.

Transport is the chief instrument of colonisation. What had we done, in this direction, before the war?

1. *Railways.*—The first railway which the Belgians built has been a pioneer work. As early as May 1898 they completed a railway of 400 kilometres, connecting the deep water port of Matadi, on the Lower Congo, with Stanley Pool, where the Middle Congo becomes navigable for more than 1,800 kilometres up to the Stanley Falls.

It was a most difficult and arduous task, but the barrier of the mountains, which had so long isolated Central Africa, was broken, and broken for the first time.

Then a concession was granted for railways which, in the centre of the Colony, above the Stanley Falls, would double the river in those places where, owing to cataracts, it was not navigable. The railway was successively laid from Stanleyville to Ponthierville, and from Kindu to Kongolo, thus connecting the Upper Congo or Lualaba with the Middle Congo, just as the latter had been connected with the lower river by the Matadi-Leopoldville railway.

The newly discovered importance of the Katanga as a great mineral centre made it necessary to connect the Katanga with the railway system of South Africa, which was done at that time, up to Kambove. During the war, this line was continued to Bukama, another line being completed between the higher Congo River and Lake

Tanganyika, from Kabalo to Albertville. These lines were absolutely necessary for the supply of our brave native troops who defeated the Germans, conquered Ruanda, Urundi and the whole country up to Kigoma and Tabora, and whose victorious and rapid blows had a decisive influence on the issue of the contest in that part of the world.

After the war it became clear that the system of railways as existing then was incomplete and inadequate.

It was first necessary to considerably develop the Katanga railways, as far as plant, organisation and rolling-stock were concerned. No less than 150 million francs were spent after 1918 with that object. Thanks to these improvements the Katanga railways are able to-day to face a traffic of more than 3,000,000 tons.

The pioneer line of Matadi-Leopoldville had become obsolete: its very small gauge (72 centimetre) chiefly attracted attention, but its real drawbacks were the stiff gradients and the short curves. A new line, new for two thirds of the distance, was mapped out, the building of which has begun. It has further been decided that the railway shall be electrified and the gauge widened to 1.067 metre, the usual African gauge. This transformation will considerably increase the carrying capacity of the railway and meet any extension of traffic which can be foreseen. The amount involved is at least 200 million francs.

But I had to take a much more important resolution. A glance at the map will show that it is an absolute necessity to link up the mining district of Katanga with the Atlantic. There was an old scheme involving the building of a railway over the whole distance from Katanga to Stanley Pool. At post-war prices, this scheme meant such a large outlay, owing to the long mileage and the very difficult country after crossing the Kasai River at Djoko-Purida, that its cost would have been prohibitive, and the railway would not have been able to compete with other lines, existing, planned, or under construction. I, therefore, took the decision to link 750 kilometres good waterway to the railway system. Water transport means a reduction from 3 to 1 in cost as compared with railway carriage; the drawback of transhipment is immaterial in the case of copper and the other raw material to be considered in that part of the colony. The length of railway to be built was consequently reduced, and the cost of exploitation also. Furthermore, the country chosen for the new scheme is much richer and it is very likely that the line will be a paying concern on the whole distance.

This railway—the Bukama-Ilebo—is in full construction. The first survey was ordered in August, 1921, the distance being more than a thousand kilometres. The actual construction was begun in March, 1923. Before the end of this year, more than one third of the line will be built, and it is expected that 1925 and 1926 will see the building of most of the remaining part; so that in 1927, if all goes well, the first trains will bring the copper from the Katanga and the cotton from the Sankuru district direct to the Kasai river, whence they will proceed by river craft to Stanley Pool and by the Congo railway to the seaport of Matadi. The cost will be from 350 to 400 million francs.

In the north-east corner of the colony, near to Lake Albert and the Sudan, we have an interesting gold mining territory known as the Kilo and Moto mines. We have resolved to link it by rail with the Middle Congo, thereby opening up extensive and valuable country for over 1,000 kilometres, and connecting the south of the colony with the north, just as the Bukama-Ilebo railway connects the south with the west. This railway scheme is at present under survey and will be extended later on to Lake Albert, by that means joining the Congo with the Nile!

At the same time several small gauge railways of about 200 to 250 kilometres are being built in the Uele district, and will bring the navigable parts of the Itimbiri and Uele rivers in communication. This extension will also open up a very rich country, hitherto hampered by lack of transport.

The total length of these new Congo railways, undertaken since the armistice—they are not merely schemes, but actually in process of construction—is between 2,700 and 2,800 kilometres. As the Belgian railway system is only 3,200 kilometres in length, and as there are already about 2,000 kilometres of railways in the Colony, you will agree that Belgium is not lacking in active help towards the development of its African possessions, especially when you consider how heavily our finances have been handicapped by the war and the non-payment of our claims on Germany.

I have only spoken of those railways which we are building at present. I purposely abstain from mentioning other interesting schemes, the importance of which I do not however underrate.

The reason is, that even without considering finance, there is a factor of paramount importance which in a country like the Congo you must on no account ignore, namely, native labour and the native labourer. All this huge railway building finally rests on the number of natives you can spare from the kraals, the fields, the fishing, and the hunting grounds. As a rule, the native, if you respect his free-will—as we absolutely and unconditionally want to do—will only engage his services for a limited term, say six months or a year. This means that for every man on the works, there is one returning home or just returned, and one on his way to engage in his turn. Now the Congo native has been made to understand that the railways are going to deliver him from the portage, which is a plague to Central Africa. He does not grumble at the work, if decently fed, paid and treated, but it is easy to understand that there is a limit which you may not transgress if you are not going to bring untold hardships on the population and excite their anger against the railway-work and the white man's enterprise.

2. *Ports and Rivers.*—Next to the railways, and in connexion with them, we are building new river ports or extending old ones: Kinshasa, on Stanley Pool, Ilebo on the Kasai, Matadi on the Lower Congo. The equipment of the rivers is a big affair. Within three years a considerable number of barges will have to be built in Europe, carried in pieces to Matadi and up the railway to Stanley Pool, and put together there in order to meet the traffic which will at the end of that term begin to roll down from the Katanga.

Naturally, a good deal of it will still go south, but the part which will come north will mean a great effort to equip the waterways with suitable craft.

3. *Roads and Motor Transport.*—In our plans of development, roads and motor transport are not lost sight of. Our last achievement has been to build the missing link in the Cairo to Cape route. The main road connecting Nyangara with Redjaf in the Sudan was completed a few months ago and equipped with motor cars.

Do tourists realise what all this development means to them? Travellers may now start from Cape Town, and, by modern mechanical means of transport, railways, steamers, and motor cars, reach Cairo without any undue exertion or risk. You may by similar means cross Africa from Dar-es-Salaam on the Indian Ocean and within six weeks reach Matadi on the Atlantic.

A four months' holiday will take you comfortably, with reasonable time for sight-seeing, from London to the Cape, thence through South Africa and along the whole Congo rivers to Matadi and thence back to Europe. No longer time would be required for the Cape-Cairo trip. But when this is said, I am bound to add that our experience is that however useful roads and motors may be for administration and travelling and also for tapping the country to feed railways and steamers, they cannot and will not develop a country like Central Africa. The reason is simple: the cost of a kilometric ton per motor lorry varies from 4 to 10 and 12 francs, which is prohibitive.

I may have dwelt a little too long on the problem of communications in Congo. There is nothing in it that you have not done on a much bigger scale in your splendid colonial Empire. My only object has been to show that to the best of our ability we are doing what is necessary to further open up the country, and I may perhaps add that we give all honest trade a fair and equal chance. The best proof is that on a total import into the colony in 1921 and 1922 of between 231,482,870 and 276,027,218 francs in value, the Belgian produce amounted to scarcely 50%. We hope to do better in future, but the figures are certainly a proof of fair play and free trade,

I now turn to the other problem which is dominating all colonisation in Central Africa. This is population.

Problems of Population.

The Congo has an area of about 910,000 square miles.

But what is the population? In a space corresponding to that where at least a hundred and fifty million people are living in Europe, and perhaps two hundred and fifty millions in parts of India and China, there are no more than twelve millions of human beings in Central Africa. And yet, with the exception of Nigeria, the Congo is more thickly populated than any of the other colonies of Tropical Africa. What are the reasons for this thin population?

General Conditions of Life.—There is a certain picture of the life of primitive mankind. Poets and novelists and some social reformers have seen it as that of simple folk, with modest tastes and no ambition, living quietly and happily on the natural products which the glorious sun and the fertile land supply with lavish generosity, and practically without pain or labour. It is a paradisiacal country and a paradisiacal life; the only trouble comes from the white man and his restless ambition and greed. That is the picture. But the truth is quite different. Insufficiently supplied with food, with scarcely any clothes, badly housed, the African native is living in very poor conditions and he is an easy prey to terrible diseases, which are rampant everywhere in the Tropics. These bad physical conditions keep the population down in Africa, as similar conditions have done for centuries in most parts of the world. Now, without a much more numerous population, living in healthy conditions and with a better economical standard, there is no future for Central Africa. As we want it to have a great future and believe in it, we were bound to tackle the problem, and just as we provide railways and ports and ships, we must build the race up anew and procure better hygienic, moral and economical conditions of life, for our black subjects: that is the mandate and the trust we are under. It is a great battle but one well deserving to be waged and won. We do not underrate the difficulties. "To raise the native from the low state of civilisation in which he at present exists," says the Admiralty Manual on Belgian Congo, p. 10, "to educate him, and to improve his moral and social outlook will be a task of the greatest difficulty." It is a problem of hygiene and morality.

Sleeping Sickness.—From a sanitary point of view, the chief enemy of our natives is trypanosomiasis or sleeping sickness. As every one knows, sleeping sickness is a disease caused by microbes which are conveyed by a fly; *Glossina palpalis* or *morsitans* is the scientific name, *tsetse* is the vulgar one. The fly sucks the parasites from the blood of infected people and goes on infecting others. So the three actors in the drama are the parasite, the fly, the infected person. The disease, if treated early, is now considered to be curable. But how to discover it rapidly and efficiently or how to prevent it from spreading? Amongst the natives, it has wrought terrible havoc.

The infection is not general in the country. Many areas are not touched by it; in others it has lately abated; generally speaking, it appears rather stationary than increasing. Nevertheless, it remains a terrible plague.

For the European, wearing clothes and using care, there is no serious risk; the number of such cases is very small, and as the patients are regularly treated in time, they are very generally cured.

But with the natives the position is quite different.

The fly seeks for water and shade; so it keeps to the lakes and rivers, just where the population likes to dwell.

In order to fight the plague, various systems have been tried—segregation and medical treatment of the infected people; transfer of the villages away from the side of the water; cutting down vegetation; controlling the native travellers; there is much good in any one of these measures but none has proved really efficient.

We are, and have been for four or five years, resorting to a system of powerfully-equipped medical missions, operating in the more infected regions, and trying to "clean" the whole of the population, so that the fly can no longer infect itself by biting infected persons.

In individual cases, microscopic observation of the blood is the natural way of detecting the disease. But for mass treatment, in parts of the country where the disease is found to be strongly prevalent, the diagnosis is generally limited to such exterior symptoms as enlargement of the glands of the neck. This rough-and-ready method alone permits the work to be carried out on a huge scale and with the necessary diligence.

These medical missions proceed methodically from village to village and territory to territory, examine all natives, treat all who are infected or suspect, keep a census of the people examined and treated, and as they advance they leave behind them trained native injectors, who continue the treatment. Second and third examinations are made at intervals. It is an enormous undertaking. In four years, in the Kwango and Kasai districts, 3,272 villages have been treated, 534,323 natives examined, and 850,000 injections given. Consider what this means in a difficult, wooded and mountainous country, with a population, ignorant and, at least at the beginning, objecting to the treatment. But consider also the results.

At the first examination, in one of the areas, for instance, the number of sick persons was 16.3 per hundred of the population; at the second examination, it had fallen 6·2%, at the third to 2.2%. Another territory gives the following percentages: 9.5% at the start, 6.5 % at the second visit, 2.2% at the third. On the average, one may say, there has been a gain of from 3 to 1 and that by continuing the system, the disease can be successfully fought.

As to the therapeutic means which are available, you all know that no absolute remedy has been discovered up to date. The usual products injected are atoxyl and emetic. A new Bayer product, No. 205, has been tried by us with success. Its action is more permanent than that of other remedies and it seems to require a less number of injections, an important advantage. An American remedy prepared by the Rockefeller Institute, has been experimented upon at Kinshasa by a distinguished American lady scientist, Dr. Pearce, and is still on trial in our Congo laboratories.

Other Tropical Diseases.—Sleeping sickness is by no means the only important disease which threatens the black man; malaria is a terrible visitation, as also are pneumonia, syphilis, framboesia, etc.

But the greatest drawback, from a sanitary point of view, is the lack of natural resistance of the native to all sorts of sickness, owing to ignorance, neglect of general precautions and backward economical conditions. The children especially pay a heavy toll to pneumonia, as the native mother, although very loving and kind, takes no measures against the low temperature at night and at the beginning of the day. What is the remedy for this terrible infantile mortality? Where white women live, in our cities, and at the missions, they are trying to educate the native mothers. The work is excellent, but is as a drop of water in the sea.

Medical Organisation.—Doctors are the backbone of any hygienic system. Their number in the colony has been largely increased. In 1918, when I took office, the number in State service was only 39. In the last budget provision is made for 126. There were no trained nurses except the very devoted Catholic sisters. These have much increased in number, and there are at present 25 trained nurses, who specially attend to the care of children. Hospitals and dispensaries are numerous. The great industrial and plantation companies are obliged, by the conditions of their concessions, to have a medical staff, and a few months ago, M. Malan, Minister of Agriculture of the Union, after visiting Katanga, paid a warm tribute to the hospital organisation, the native camps and sanitary arrangements in the mining district. He said that the organisation in the factories, for which the Union Minière is responsible, was not inferior to that of the Rand. The Missions do much valuable work in the same direction. But when one considers the extent of the country and the ignorance and prejudice of the illiterate native, it is clear that additional measures had to be found. After carefully studying the problem with our medical staff, during my inspection journey through the Congo, Kenya, and Uganda, I came to the conclusion that the native himself ought to be enlisted in this battle for better hygienic conditions and that the practice of the medical profession in the Congo ought to be industrialised to a large extent.

Schools for Native Medical Assistants.—It was, therefore, decided to create in different parts of the colony, six schools for the training of native medical assistants. These six schools are at work. They give a three years' course, chiefly practical, and they limit themselves mainly to the classical treatment of five or six of the principal diseases, prevalent in the Congo, to elementary hygiene and small surgery. The intention is that these coloured medical assistants shall work under the supervision of the white doctor or at least of the administrator, or the missionaries. There are some difficulties in the way of recruiting a good class of pupils, but the natives seem eager to take up this career; the "medicine man" has always been greatly honoured in the African village. We have also increased and continue to increase the white staff of the European doctor,—trained nurses and male sanitary assistants. With the same object in view I obtained power from Parliament to the effect that the young priests preparing for missionary work and subject to conscription should be put at the disposal of the Ministry of the Colonies for military training and service. I organised this military service for the colonies on a medical basis; there is no more efficient warfare in Central Africa than fighting tropical diseases. The young gentlemen referred to are getting at one of our

Universities a year's course of medical training, in view of their future activity in the tropics.

The final object of all these reforms and developments is that the doctor shall no longer be compelled to work alone and individually as in Europe, but be in command of a numerous group of white and black helpers, chiefly the latter, who may extend and multiply his action. Our medical methods in such a primitive country do not aim at perfection, but at obtaining with the available means as much efficiency as possible. This cannot be done except by organisation. Thus we are building up gradually a system by which the European doctors will be the officers of a sanitary army in which black medical soldiers will play an important rôle.

The native medical schools have another and more general merit. Rational and sound ideas of sanitation and hygiene will penetrate more easily into the natives' mind if they come to them from men of their own race, and we hope that eventually the Congo will see the end of the witch doctor, who is doing so much harm. At present the native in the Congo does not believe in the natural cause of diseases. All are to him the work of evil spirits. Well, these young medical students see the evil spirit under their microscope; they know that quinine or atoxyl kills it, and that incantations and witchcraft will not, and so—at least on this limited ground—something will have been done to build a bridge between the European mind and the black mentality.

This leads me to say a few words on our views of the education of the black man.

Education.—We believe in education. We do not believe in Europeanisation.

At an earlier period, we were eager to think that our primitive African subjects were likely to understand and accept our abstract intellectuality, our respect for logic, our belief in progress, justice and liberty, and that they would admire the indomitable energy and activity of the white man. They do not. They ignore abstract ideas and principles; they live among positive, concrete facts, but they entirely transform them by their unbounded imagination. The shadow they see, or think they see, the dead they have lost, the big rock which bars their path, the tree which falls, the leopard which kills a man, have all a spiritual force within them and this force is to the native mind a concrete reality, a sort of living being or force with hatred and love, of which due account is to be taken if it is not going to bring you damage, disease and death. What sort of dialectics this turn of mind is leading to may well be illustrated by a quite recent instance. When, a few years ago, the two first aeroplanes of the King Albert line between Stanley Pool and the Stanley Falls came down at Gombe, the natives made up their minds that one was a male and the other a female, and they showed our officers which was the male bird and which the female. Their reason appeared to be that the male had come down first, seeking a way for his wife, as some birds will do, or as the native might himself do in an unknown country. So the modern flying machine had acquired a soul and a spirit, and habits and ideas of the animal species to which it was considered to belong. By a mere effect of imagination a mental comparison or image had quickly grown into an objective reality. Many other instances might be given, and the position is in no sense peculiar to our African population.

It is because the difference in mentality is so great that the problem of education in the Congo is so difficult. To simply import our European school system, our European text-books, languages and ideas, must necessarily lead to waste of time and labour, to anarchy and discontent. We might rely on the natural spirit of imitation in the black man and aim at assimilation; but we think that in so doing we should only manufacture third class copies of Europeans. We wish instead to try to make a better African, stronger, more efficient, of a higher morality. But that we can only do if our educational system is adapted to his mentality; if its aim is to develop him and not imitation of us, if it seeks its basis in the character, nature and traditions of the native. To that effect technical, manual and agricultural education in the native languages seems to be the right system. Respect of the native institutions is a natural corollary to that education and has become the very basis of our policy.

Native Institutions.—We find that the white man has often a natural impatience with some customs of the negro which although not cruel or inhuman hurt our feelings; it is very simple to call them barbarous and make a clean sweep of the thing.

But these primitive folk have rights of their own; they have their view of life and family organisation; we may and must induce them to correct what is wrong; but it would be hard, unfair and dangerous to do this at once, by legislation or by brutal and drastic interference. We think that we must leave things to gradually develop, and in that way build up an African civilisation.

A very striking example of the good results which may be achieved by respecting native institutions is supplied by Ruanda and Urundi, the two mandate territories entrusted to our care.

Whereas in many parts of the Congo colony, the big chiefs have formerly, and not without reasonable motives (such as rebellion) been removed and their dominions often divided up between their sons or other chiefs, in Ruanda and Urundi we made it from the beginning our guiding principle to maintain the existing political organisation and to rule through the two native sultans. The Watuzi, the dominant class, were kept in possession and power, but the exactions and abuses under which the subject race was often labouring were suppressed. In both principalities we have rather strengthened the central power.

The results of this policy are very good! The country develops well and has a bright future before it. The generous, and I may say gentlemanlike, way in which Great Britain settled the boundary question along the river Kagera has done very much to increase the prestige of the white man. We made it clear to the native rulers that the matter could only be settled on grounds of justice and fairness. They were polite but very sceptical. I quite remember the attitude of King Musinga when I tried personally, in his *Boma*, at Nyanza, to explain the position to him: our friendship and alliance with Great Britain, the impossibility of a conflict, your love of fairness and equity. He said:—

"But, Boula Matari, you say you love me and my family and my people and want us not to be deprived of the land of our ancestors."

"Yes, this is what I say and think."

"Well, you have fought and beaten the Germans?"

"Yes."

"Why, if you love us, don't you fight and beat the English?"

But at present, when the Kisaka region, after having been given up, has been returned to Ruanda, King Musinga and the elders said: "Yes, we see that the white men love justice and listen to reason."

The Chairman (Mr. Ormsby-Gore) has had a most honourable part in this arrangement and, may perhaps feel as I do, that this appreciation by that native ruler far away at Nyanza, in his mountains of Ruanda, is well worth remembering and that politics have not often in store for us prizes of such moral value.

In the Congo proper, we are following at present the same methods. Great care is taken to respect tribal life, native institutions, native chiefs; to organise native tribunals and councils; to educate native clerks; to get under all forms native co-operation for the administration of the country. And this method works very well.

I have thus outlined our general policy for the development of the Congo and now you may well ask two questions: first, what progress is being made; secondly, is the colony paying or at least self supporting?

What Progress is being Made?

The first and most considerable progress is that peace, order and security are reigning from the Atlantic to Lake Tanganyika and from Rhodesia to the Sudan. To appreciate what that means to Africa, let one remember that the Arab slave traders were carrying their horrible raids into the heart of the Congo as late as the beginning of the nineties. To annihilate their domination took several years of hard and dangerous war. The difficulty and merits of the Arab campaign are not known enough abroad. The Belgian officers in that war may justly claim a great share of the blessings which Livingstone in his last words promised to those who would save Africa from the curse of slavery.

The native is slowly beginning to enjoy individual freedom; he is able to move from one part of the country to another without being captured by hostile tribes and reduced to slavery. Domestic slavery is rapidly disappearing, as it is under no form recognised by us and as the European establishments and factories supply a living and freedom to the domestic slave who wants to leave his master. The liquor traffic is strictly forbidden. The native has learned the use of money, which in a few years has spread wonderfully. Labour in the mines and factories is becoming

more popular as care for the welfare of and food for the native labourer increases. The Union Minière, for instance, had formerly to recruit or import all their labour; to-day nearly 35 per cent. of their black workers are voluntarily presenting themselves, as Europeans would do. The *Forminière*, the diamond company, has had a not less favourable experience. Many natives are becoming small traders in European wares and are doing well. All this means a marked economical progress, but the moral advance is slow.

Moral progress is greatly helped by the admirable mission work which is done by the two Christian Churches on a large scale and in the most generous spirit. Our experience is that the Congo native is an essentially religious being. His intellectual life is enveloped in mystery. Under European influence much of this will go, but nothing good will result if no new creed of superior moral value takes the place of the old belief.

The further development of the country is likely to considerably improve the standard of life of the population and render possible a better family life, although, as everywhere else, the first decades of contact between two civilisations so widely different are meaning great risks to the inferior race; to this, the moral state of the big black settlements near European towns is a sad proof. But with a second generation and better adaptation, progress may be expected.

The economical evolution of the country is therefore very important for the future of the native population.

What are the chief features of this evolution?

The first exports from the Congo were simply the raw produce of the forest or the hunting ground: rubber and ivory.

Some plantations of cacao and coffee have been created. Rubber has also been planted. But it will remain the honour of a great British firm to have started the first really important enterprise based on cultivation and industrial organisation. Messrs. Lever Brothers, in creating the Huileries du Congo Belge, have given the commerce and industry of palm kernels and palm oil such a development that these branches have become the backbone of Congo vegetal exports.

The colony is second only to Nigeria in these respects.

The export of copal, a gum which is employed in the manufacture of varnish, which was only about a thousand tons in 1910, is to-day averaging from 12,000 to 14,000 tons. Cotton was introduced a few years ago by the Government and is a great success. Lack of modern communications and the demand for labour by the new railways are hampering the extension of this industry, but no doubt it will increase very rapidly when the new system of railways is ready. Length and quality of the fibre are good; several ginneries have been established and the native likes to plant cotton.

As to administrative survey and co-operation, we have taken as an example the excellent system which I saw at work in Uganda.

Important plantations of cotton can be established in the country which the new railway—Bukama-Ilebo—is traversing; the combination of copper and cotton may prove very favourable freight both for railways and steamers.

Other efforts have been made to improve and increase the cultivation of the land, especially by the native in and around his village. However, most of the agricultural work is still to be done. The object is not neglected, but it is natural that in an industrial country like Belgium the mineral wealth of the Colony should have first attracted attention.

From the mineral point of view, the history of the Congo is like a fairy tale. When, in April, 1908, I spoke in Parliament in favour of the annexation of the Congo, the *Times* correspondent wrote:

" M. Franck gave a glowing description of the potential wealth of the Congo, and his high spirits were infectious, for the faces of his fellow annexationists wore the same expression as may be observed at a company meeting after a good half year. His description of the Katanga copper belt was quoted from reports of English engineers and an English Parliamentary document. It is to be hoped that no mistake has been made in the figures. As M. Franck observed later, there are three kinds of inexactitudes: errors, statements contrary to the truth, and statistics—for if Katanga were for any reason to fail to justify the confidence placed in it, those whose shrinking from the cost of the Congo is overcome by the prospects of 'a richer Rand' might find in this event additional proof of England's perfidy."

When I took office the tonnage of copper produced was varying round 20,000 tons a year; the figure for 1919 was even a

little lower. Now the copper produced last month alone was 7,500 tons, making an average of between 80,000 and 90,000 tons a year. This places the Congo third in the world production, only the United States and Chili taking precedence. And this is not the end. The reserves are practically unlimited. The cost of production is low; a few years ago, the Katanga factories were able to keep working when nearly all mines were closed.

A new type of smelting furnace has just been tried, which will diminish considerably the working expenses, and when the leaching plants have been completed, the low grade ore will be capable of exploitation. An output of 200,000 tons before we are ten years older will be nothing extraordinary, and this would bring the Congo to the second rank amongst the copper-producing countries of the world.

Copper is not the only mineral wealth of Katanga. Tin exists in great quantities, but it is not yet mined in full, as there are still difficulties of transport. Coal has been found. The Shankishia coal near Bukama is of a good average quality; but up to date none of this coal can be used for the making of coke. Iron ore is found in enormous deposits of high grade up to 65 per cent. of iron and more; but as long as Tropical Africa is not itself a great consumer of steel, or as long as some technical innovations do not occur, these iron deposits are likely to remain a valuable reserve: distance to the coast is at present too great.

On the other hand, precious stones and precious metals are an asset of immediate value. In 1908, the Compagnie Forestière and Minière carried on a very great deal of prospecting outside Katanga and nearly exhausted its capital without any result of importance, when a tube with a small white stone, found near Tshikapa, reached Brussels. It was a diamond. Further researches proved that extensive deposits existed in the southern Kasai district, in the gravel of the river or of its banks. Several beds were discovered; others are still being found in the neighbouring territories. Owing to arrangements which I took when in office, the throat-cutting competition which did so much harm in South Africa at the beginning of the diamond industry there has been avoided. All the concessions are controlled by one organisation, over which the Government is able to exercise the necessary action which public interest may require. So the valuable deposits are worked to their best economical possibilities, and with due care for the native population. The progress has been remarkable. In 1918, the output was 178,000 carats. In 1913 it amounted to 539,576 carats, which is about 20 per cent. of the South African output.

It would have been a pity for us if gold had not kept pace with the diamonds. Well, we have been fortunate also in this direction. Gold placers are successfully mined at Kilo and at Moto, in the North Eastern part of the Colony, near Lake Albert. The output is rising and was last month 388 K°. It is alluvial, but quartz veins of importance and well workable have been discovered. In order to exploit them in industrial conditions, heavy machinery will be necessary. The plan is to await the erection of the factories until the railway reaches this part of the country. In the meantime we exploit the placers, not directly, but through a commercial organisation. So a rush of gold diggers has been avoided, greatly to the benefit of and with regard for the native labourer: food is not available in unlimited quantity, as long as the rail will not bring it to the mines; the district has only a thin population; so any excess in working the deposits would mean great hardships to the black tribes.

The story of radium in the Congo is still more interesting than that of gold and diamonds.

Nobody was thinking that there might be radium ore in the Congo, when, during the war, a mineral of a very special yellow colour attracted attention in Katanga. It was sent to Europe for analysis. The presence of radium was ascertained, and the Congo ore proved so rich that the Americans, who were until then by far the most important producers in the world, have shut their mines and are selling the Congo radium: so the latter is ruling the market. As the Government has an interest in the matter, the price has been seriously lowered in due regard for suffering humanity.

A new discovery is cobalt, also in excellent conditions as to quality, quantity and cost of production. The factory is about to be in working order. Cobalt is at present of limited use, owing to its high price; it is employed for colouring purposes and also as an addition to steel, which it protects against oxidation. But with greater quantities and lower cost it may well obtain

new and increased applications. Here also we wish to make progress.

Is the story of the Congo's mineral wealth to end there? Nobody can say. But experts are firmly convinced that when the eastern and north-eastern parts of the colony have been opened by the Stanleyville to Kilo-Moto railway, there will be most remarkable surprises! Oil may exist in the Mayumbe, and certainly the extraordinary underground of Katanga has not revealed all its treasures.

In many cases the great distance from the sea is a drawback to the export of heavy metals, but the low cost of production is a set-off. The native labour day in the Katanga will not cost one half of that on the Rand, while in the more remote districts, Kilo Moto for instance, it is only one fifth or one sixth.

The Black as Artisan. No Colour Bar.—The whole of this industrial development is accompanied by equality of treatment and full opportunity for black labour. The Congo negro is admitted to all work which he proves able to do. Many natives become good artisans, engine drivers and so on. Nothing like the colour bar of the Rand exists in Congo. A few years ago, agitators, coming from South Africa, tried to introduce this distinction in Katanga. They were at once politely but firmly sent back to their own country by order of the Government. They tried to get the Belgian Labour Party to support them. They met with a deaf ear. We consider it against public policy that in his own land the black man should not enjoy the fullest opportunities for all class of work and thereby be able to raise himself to any level he may be able to reach. The Belgian white artisan entirely agrees with these views, and his feelings are fostered by the consideration that most companies pay him a premium for every black apprentice he educates to the trade.

Some of the companies have established industrial schools and are rapidly educating large numbers of black artisans. The Government and the missions have long been on the same path. But the interesting feature of the companies' enterprise is that they try to train several hundreds of artisans, by very practical methods with great care for specialisation. The progress of the industry will therefore prove a bounty to the native. Already he is, in the labour camps, better housed, supplied with better food and blankets and more able to buy clothes than in his native kraal.

There are, however, at present also drawbacks. Tribal morality and tribal sanctions disappear amongst the labourers of the big industrial concerns, but the good effect of a more decent and better life is not always appearing at once. Women are scarce; immorality is rampant and the birth-rate is very low. Efforts are strenuously directed to remedy this bad feature in the reactions of two grades of civilisation, so widely different; after a time, adaptation will allow of the reaping of the full benefits of economical progress.

Finance of the Congo.

Is the Congo paying? There has been a school of colonials in Belgium who are of opinion that the Congo ought to pay or at least be self-supporting. I do not belong to that school. A new country with its enormous difficulties wants a great amount of capital to be invested in it. The required degree of investment can scarcely be expected from private enterprise if the Government does not give an example of confidence in the future of the colony by adequately equipping the country and duly administering it and educating the native. Before the war the former view was dominant, and the colonial budgets of that period show it. I was fortunate enough to bring the conviction home to Parliament that those who wish to secure a good harvest must be willing to till and sow with an active and generous hand. It was agreed that during the erection of the great public works, and before they are completed and able to earn the necessary revenue, the metropolis should help the colony. This help has taken the form of an annual grant-in-aid of 15,000,000 fr, which has materially assisted the colony to float the necessary loans. But the market for public loans is not unlimited. Consequently a new financial organisation was planned and prepared by me before I left office.

The very extensive land concessions at the time of the Independent Congo State have practically all been bought in or liquidated in some form by the Government. But mines and mineral deposits are still the object of concessions as in all countries. It is the best means of procuring good management by business men on commercial lines. But the Government of the colony, when granting such concessions, has had foresight enough to reserve for itself a substantial share in the net profits.

It appears to us a sound policy that such valuable natural assets as the copper, diamond, and gold deposits should not be simply given away for the pains of prospecting and working them, but that the community at large should get its due share of profit, so that the wealth extracted from the soil should help to defray the great outlay on sanitary and such work, and on development done for the benefit of the natives and the colonists.

We begin to enjoy the advantages of the system. Two of the companies referred to will pay this year to the colonial exchequer not less than 24 million francs, and the net profit of the gold mines, in which the Government keeps the whole interest, will amount to the same sum. This means together 48 millions.

The valuation of the shares and participation which the colony possesses in that way is so important that on 1st January, 1924, it exceeded the total debt of the colony. The problem now was how to make use of these assets for the execution of our great programme of railways, public works, hygiene and education? It would have been unwise to sell these assets, which keep the control of all these valuable mines under the nation. It was resolved that these shares, debentures and participations should form the capital of a financial or holding company, which will issue loans on account of the Colony and on these assets. The Colonial Government will guarantee a fixed interest. There will be also attached to the new stock, thus issued, a right of participation in the dividends and profits of the colonial shares and debentures; so the man in the street, the peasant on his field, the clerk behind his desk, if they invest their savings in that way will find themselves indirectly shareholders of the copper mines, the diamond-fields, the gold placers, and the radium factory of the Congo. The money thus obtained will be placed by the Government in stocks or shares of the various railway companies which are building the new lines and thereby contribute to the development of the country. In their turn these stocks and shares will be vested in the holding company so that the success of these lines will increase its revenue and supply further credit to facilitate the new emission of loans.

On one hand, you see the Colonial Government considers itself a bad merchant and a poor manufacturer, and leaves the working and management of business to business people; on the other hand, it duly appreciates that the general interest is at stake in several forms of colonial enterprise and gives effect to that consideration by the share it keeps in them or the monetary means it supplies.

I think this to be a quite modern method of public enterprise.

We hope in that way, to supply on favourable terms, our vast development works with the necessary capital and we increase at the same term the general interest of our people in the colony.

This brings me to the end of these very incomplete remarks.

The Congo is at present appealing very much to the mind and heart of our ordinary citizen. The basis of a real colonial career has been laid for the Belgian youth by the creation of the Colonial University at Antwerp. As in all colonising countries the man at home is not sparing in his criticism of colonial administration, but he has learned to feel and love the greatness of colonial enterprise and the lofty aims of human and modern colonisation.

The Congo has enormous potential wealth. It has a great future. It certainly adds a splendid asset to the possessions and credit of Belgium. But it is like the old hostels in Spain, of which it was customary to say that you would find within their walls all you had brought there yourself. Nothing in the Congo would have developed but for the foresight, courage and genius shown by King Leopold, but for the reforms introduced, the pains taken, and the capital invested by Belgium. Nothing will fructify without a continuation of a firm policy of strenuous activity, strong financial support and fair play to all.

We do not believe that in the Congo we are showing new ways to our elders and betters in the colonial field. We are quite content to take a few leaves out of their book and pleased if impartial judges consider that, in a difficult task, we modestly do our best. There is no colonial history without great risks and dark pages. But nobody who reads history, nobody who has gone through the marvellous exhibition now open at Wembley, can be blind to the immense progress and blessings which colonisation, as the British people and the modern mind understand it, have brought to the world and to humanity.

DISCUSSION.

THE RT. HON. SIR FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., said he was sure he was voicing the feelings of the audience when he thanked M. Franck for his extraordinarily interesting address. Some years ago there was a belief throughout England that in the times of the Independent Congo Free State the country was very much misgoverned; and that feeling had been shared by a large section of the people of Belgium. It was, therefore, particularly desirable that M. Franck should give an illustration of the great revolution in methods which had taken place in the Congo since it became a Belgian colony. This revolution in the methods of government in the Congo was of extraordinary interest to all Powers exercising control in Tropical Africa. In this transformation M. Franck, not only from his long tenure of office as Secretary of State for the Colonies, but also from his personal visits to the Congo, could justly claim to have had a very large share.

M. Franck had stated that in his view the whole problem of the Congo might be summed up in the two words—"population" and "transport." He had told them a great deal about the way in which the arterial system of railways had been and is being developed in the Congo—and a most excellent system it seemed to be. The next point was: What were to be the feeders of those railways? On that point M. Franck had not said very much. Personally he (the speaker) thought the narrow gauge feeder line was a mistake; it meant duplication of workshops, rolling-stock, etc., and if bridges were made broad enough and strong enough to carry a heavier line later on, its cost was practically as much as that of the standard gauge. Nor did he himself think that roads offered a final solution. He agreed that motor transport was too costly for Africa, and motor roads cost there nearly as much as the light line itself. Not only was their initial cost great, but their upkeep in a tropical country, subject to tropical rainfall, was practically prohibitive. Consequently the solution, in his opinion, was to find some method of cross-country transport such, for instance, as the Citroen car, or some form of wheelless vehicle, which could go across country and do without expensive roads. The British Empire Cotton Growing Corporation had undertaken to investigate that question, and had appointed a committee, who had already, he believed, presented a report. He hoped they would now go into the kindred problem, the question of a cheap liquid fuel. Those two problems—a cross-country method of transport and a cheap liquid fuel—were the ones which most concerned those interested in the development of transportation in Africa.

With regard to population, M. Franck had described the various efforts which had been made to improve the condition of the natives, and he would only add one word on that point. As a Member of the Mandates Commission, he had been struck this year, when examining the Urundi Reports, to learn that the itinerant trader was completely prohibited in Urundi. The reason given was that he was a carrier of disease. He (Sir F. Lugard) thought this country had something to learn in that respect. In West Africa, in particular, the people were very keen traders. The itinerant trader went everywhere now under British rule, and in his opinion such a man should be subject to licence and medical inspection. Another lesson which we might learn in connexion with our British possessions was the system of training native assistants to be fairly skilled in the treatment of five or six special diseases. With intelligent natives we could really get some measure of skill and knowledge in regard to four or five particular diseases without attempting to make them general practitioners.

Generally speaking, he thought the policy which M. Franck had outlined—the idea of the country being ruled through, and by the aid of, the native Chiefs, the conception of individual freedom to the native, and so on—was one which would find warm approval in this country.

In conclusion, he desired to say one word with regard to what M. Franck had said in respect to concessions. The chief criticism of the old régime in the Congo was the enormous concessions given to individuals. The task which the Belgian Government had had in buying out or liquidating those concessions must have been a very difficult one, and we congratulated them heartily on the fact that they had succeeded in doing it. The present-day concession was a very different affair. Instead of the concessionaire exploiting the native without any corresponding advantage to him, the former was now called upon to establish schools, to provide medical officers, to establish dispensaries, and finally, to share the profits of the enterprise with the Government. He (Sir F. Lugard) thought the system was an admirable one, and he hoped that there would be much profit to share after all those conditions had been carried out.

MR. H. R. GREENHALGH said Lord Leverhulme, who had had to leave the meeting in order to keep a very important engagement, had asked him to express his grateful thanks for M. Franck's references to his Company, and to say that, in all the developments which they had undertaken in the Belgian Congo, they had at all times received the greatest possible consideration and help from the Administration under M. Franck. Personally he would like to take the opportunity of saying that he himself had had the pleasure of touring through the Congo twice, and that he had been greatly interested in, and could bear witness to, the very excellent administration which at present prevailed in the Congo.

MR. E. TORDAY agreed with Sir Frederick Lugard's statement that the itinerant trader was an extremely great danger as a carrier of disease. As a proof of that, in those parts where such men did not exist in the Congo, sleeping sickness was absolutely unknown.

Concerning the introduction of European civilisation into Africa without destroying that which already existed, one was accustomed in speeches by politicians to hear a lot of pious wishes expressed, but M. Franck had done very serious and considerable work in furtherance of that idea. It was a very ungrateful task, because one had to appeal to the electorate in terms of money, and one could not show any quick return. He believed the establishment of a Colonial University, and of the system of sending young Belgian students to study native languages, would bear very good fruit in the future, though at present it might be considered unproductive. One could not in a few years educate the native up to a civilisation which had taken Europe two-thousand years to acquire, and it would be a great mistake to destroy that which already existed in Africa, much of which was very admirable.

The Chairman (The Hon. W. G. A. Ormsby-Gore) said he would like to say, as late Under-Secretary for the Colonies in this country, with what extreme interest he had listened to M. Franck's lecture. When one investigated the problems, they were, he believed, all coming more or less to the same conclusions. The first thing which had come into his mind when M. Franck had, quite rightly, justified what was being done by European Powers in Africa, had been the memory of the English philosopher Hobbes, who first opposed the prevailing Continental conception of the "noble savage." Rousseau had said that if Europe could only get rid of its kings, priests and lawyers, and return absolutely to nature, everyone would be happy ever afterwards. It was easy to think that in Geneva. It was not easy to think it in Africa; and the English philosopher was really right. The life of primitive man in his natural conditions in Africa was, in the words of Hobbes, "poor, dangerous, nasty, brutish and short." Tropical disease, local wars and many barbarous customs had to be stamped out before all that was best in the native outlook and in the native capacity could be developed. Before the moral and intellectual, and even political, development of the native of Africa could take place, the economic development of the country was absolutely essential, both to provide the native himself with freedom and wealth to advance, and to provide the State and the country with the means to help him. It was perfectly clear that, mistakes having been made in the past, we were approaching an era where there was common ground between the official, the missionary, the merchant, etc.; that we were entering an era in which all realised that we had, if only on the grounds of self-interest, a common interest in the intelligent development and the true welfare, material and moral, of the native. What M. Franck had said about the experiments in the Congo in regard to the selection of a certain number of natives as medical assistants found a counterpart in only one British territory, Uganda, where, owing to the scourge of syphilis, we had, with the very greatest success, trained a few natives as medical missionaries, as well as practitioners, to deal with that specific disease.

Everything seemed to point to following the advice which M. Franck had given, namely, that in Africa we should not always seek perfection, but should be content to advance one step at a time, and to make the utmost use of all the means to advance, especially those indigenous in the country. What M. Franck had said about the religious character of Africa was being more and more recognised in education and other things. The real difficulty was that, in spite of the fact that so many African natives seemed to be cheerful persons, in the past the lives of the people from birth to death had been surrounded with fear. It had always struck him as extraordinary the degree to which fear had entered into the lives of the Africans—not merely fear of their neighbours and of the physical disasters which might suddenly come upon them, but the haunting trees, the haunting animals—the general hauntedness of Africa. That consciousness of surrounding evil spirits was one of the things which was most difficult to eradicate or to replace by adequate restraint and an influence which would enable the natives to build up a new morality not based on fear.

M. Franck had referred to the question of education. He himself, with Sir Frederick Lugard, had been engaged that morning on the Advisory Committee which had been established in this country in connexion with African education. The Committee was started last year when he was at the Colonial Office, and he thought it had only been started just in time. The secretary of the committee had just arrived back from East Africa, and Sir Frederick Lugard asked him: "Have you brought back any text-books which are being used in the schools?" The answer was "Oh, yes; I have brought back 200." He (the speaker) had shuddered to think of those unfortunate Africans—200 English text-books. Everyone knew what the English text-books in our own elementary schools were like; and the disastrous results they were very often producing in this country. What still more disastrous results might be produced in Africa! We were, on the lines which M. Franck had laid down quite rightly, at the very beginning of the subject of the education of the native for life in Africa, with all that that meant. That was the great point.

It had been very kind of M. Franck to mention that the rectification of the frontier of Urundi, in which he (Mr. Ormsby-Gore) had a small part last year, had proved of satisfaction to that remarkable people. If it had not been for the existence of the Mandate system, and of the League of Nations, there would have been no means of getting any rectification when the facts had been ascertained.

The future of the Belgian Congo would be watched with the greatest and most sympathetic admiration by all British students of Colonial administration. It was a great stimulus to those who were engaged upon the problem in Great Britain to hear how

another Colonial Power, which was playing an honourable and distinguished part in the civilisation and development of Africa, was tackling, and tackling so nobly and so successfully, the problem which faced it.

MAJOR SIR HUMPHREY LEGGETT, D.S.O., R.E., said that as a member of the Council of the Royal Society of Arts, it gave him great pleasure to move a vote of thanks to M. Franck for his lecture, and also to Mr. Ormsby-Gore for presiding. Mr. Ormsby-Gore had made such subjects as M. Franck had dealt with peculiarly his own. In the field of politics there was room for opinions many and diverse, for "crankiness," for preconceived ideas, for empirical views; for lack of foresight and inability to keep abreast of the times or, what was best of all, to go ahead of the times. Mr. Ormsby-Gore had referred to the haunting fear of the African native—how he was haunted by strange fears of the unknown; but he (the speaker) ventured to think that the Government of this country had sometimes in the past been haunted by another kind of fear in connexion with Africa, namely, a financial fear, and that it had not put into Africa that financial backing without which, as the Chairman had pointed out, nothing could be done. After the building of the Uganda Railway, an undertaking mixed with many political issues, there came a long period when it had been very difficult indeed to extract money from the Treasury with which to lay a foundation for the future of Africa. M. Franck had shown how Belgium, with great vision and great courage, and something more than courage, with knowledge and clear insight into the potentialities which were there for development, had not hesitated to lay down plans which would carry her, not for a year or two ahead, but for long periods ahead, so that the future of her great Possession was indeed assured. The plans of which M. Franck had spoken that afternoon involved an expenditure which the Belgian Government, under M. Franck's guidance, had earmarked, or implied its intention to provide, of no less a sum than twenty millions sterling. With the assurance of that sum one could see how the development of that great territory could be taken in hand by statesmen and administrators with a certainty that they were going to produce results—and great results. They could lay down plans, and they could be sure that their plans would not fail through the stoppage of financial supplies. They clearly did not share the haunting fear which the native of Africa had in his little way. The Government of Belgium in its African policy had no fear; and he trusted that Mr. Ormsby-Gore, who had done so much to impress upon the British Treasury the future greatness of Africa, would, as a result of his very important mission to East Africa, come back more convinced of the great possibilities of those territories, and would impress still more forcibly upon the Cabinet of the day, and the Treasury, the potentialities of Africa.

The Royal Society of Arts was formed more than 150 years ago for the development of arts, manufactures and commerce. In those days nobody had thought of the centre of Africa. It was only during comparatively recent times that the Society had been thrown open to such subjects as M. Franck had dealt with that afternoon. It was only in the period referred to that the Council of the Society began to invite distinguished administrators and statesmen of our Allies to address the Society so that we could learn from them what they were doing and could see how we might co-ordinate. That brought him to the point that he desired to suggest to the Chairman and to M. Franck, namely, that, just as in learned Societies, such as the Royal Society of Arts, people came together and talked very frankly, so, more and more, co-ordination and consultation should be arranged between the administrators, not only of the different British territories, but of those of our Belgian and French friends. The more we all pulled together the more we should learn, and the more successful would our efforts be.

SIR SIDNEY HENN, M.P., in seconding the motion, said the address of M. Franck very largely coincided with the thoughts that had been coming to his mind over the last few months when he had been interesting himself rather closely in matters connected with the African Colonies. He quite agreed that the two great questions were transportation and population. He thought that was the right order in which to put them, because, although in many respects the question of native population was really the most important, nothing could really be done of an effective character without first of all providing the necessary transportation; and in that connexion he had been pleased to hear the reference made by Sir Fredrick Lugard to the fact that in the word "transportation" not only the question of railroads was considered, but the even more difficult question of cross-country traffic. He fully agreed with what Sir Frederick Lugard had said upon the matter.

M. FRANCK, in acknowledging the resolution, said he thought the unanimity of opinion which hade been expressed about the real aims of colonisation to-day would lead to results which would be a victory for humanity and justice.

GENERAL NOTE.

THIRTEENTH CENTURY GLASS-PAINTING.—With the generous assistance of Sir Otto Beit and the National Art-Collections Fund, the Victoria and Albert Museum has recently acquired a fine panel of 13th century stained glass. The panel, about twenty inches square, is in a remarkably good condition, very little decayed and practically free from restoration. It shows a saint disputing before an audience, and is a typical example of the bold conventionalised style of the thirteenth century. Its place of origin is unknown, and it belongs to a period of stained glass design in which it is very difficult to make a distinction between the schools in France and in England, but the history of this particular panel makes it probable that it is English, and in any case it is an example of the art of stained glass at the height of its achievement. It is exhibited among the 13th century stained glass in Room 110.

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PROCEEDINGS OF THE SOCIETY.

COBB LECTURES.

CERTAIN FUNDAMENTAL PROBLEMS IN PHOTOGRAPHY

By T. Slater Price, O.B.E., D.Sc., F.I.C., F.R.S.

(Director of Research to the British Photographic Research Association).

Lecture I.—*Delivered March 24th*, 1924.

The modern photographic dry plate or coated film consists essentially of a suspension of fine particles of silver bromide in gelatin, this being spoken of as a photographic or sensitive emulsion. Although gelatin had previously been used as a medium in various experiments with silver salts, it was an English amateur photographer, Dr. Maddox, of Liverpool, who, in 1871, first used a gelatin-silver bromide emulsion to make a dry plate. Very little notice of this was taken, however, until 1873, when Burgess placed on the market an emulsion made by a secret process, and Kennett patented a quick and easy method, which was quite successful, of preparing gelatin emulsion plates by using a "sensitive pellicle," that is, a pellicle of dried sensitive emulsion. Since that time progress in the manufacture of dry plates, coated with gelatin emulsions varying enormously in sensitivity and in the uses to which they may be put, has been very rapid, and the excellence of the products produced to-day is attested by the fact that, with suitable precautions, they may be used the wide world over, notwithstanding the large variations in climatic conditions.

Without intimate knowledge of the subject one might think that the high standard of present-day manufactures is due to exact and detailed investigations having been made of the chemical and physical properties of gelatin and of the effect of variations in these properties on those of the sensitive emulsion produced. Such an assumption would not, however, be altogether correct—indeed, one might say that it would be far from correct. Although the manufacturer, as a result of the experience gained over a long period of years, can produce photo-sensitive emulsions having very varying properties, yet, as far as I am aware, it is not known with anything approximating to certainty what is the cause of photo-sensitivity and why the various processes used produce the required results. It is a matter of common knowledge that if the same gelatin is sent to two different firms, the one may reject it as unsuitable, whilst the other is just as likely to say that it is eminently satisfactory. Apart from certain simple preliminary tests, the final and conclusive test of the emulsion maker is always the practical one of making an experimental emulsion and seeing if it has the desired properties.

The question to which an answer has to be supplied is: What particular properties does gelatin possess which make it particularly suitable as an emulsion medium? A complete answer to this question would have to deal with both the chemical and physical properties of gelatin, but at the present time it is very incomplete, owing to the limited extent of our knowledge. As far as the chemistry of gelatin is concerned, it may be said to be in its infancy, both with respect to our knowledge of what happens when it is prepared from bones and hides, and also as regards its constitution. Belonging as it does, to those complex substances, the proteins, its chemical investigation is a very difficult problem, and essentially progress has only been made in the examination of its degradation products, which consist mainly of amino—acids. It is very doubtful whether gelatin has yet been obtained as a definite unitary product, although considerable progress has been made in this direction by Schryver, and the purest photographic gelatins probably contain varying amounts of degradation products or other organic impurities, in

addition to inorganic matter, which constitutes the ash. At present, there is no satisfactory method of estimating the amount of these degradation products, so that a suitable method for differentiating chemically between photographic gelatins, which are ordinarily of a very high state of purity has yet to be devised. There are, however, certain impurities which should not be present in more than negligible quantities, and which can be detected by the ordinary methods of analysis, as, for example, copper, lead and iron. Organic sulphur, reducing substances, and greasy matter should also be absent.

In view of the complex chemical nature of gelatin it is not to be wondered at that the enormous literature on the subject consists, to a very large extent of accounts of the results obtained in the investigation of its colloidal properties, a knowledge of which, as will be seen later, is very important when dealing with the photographic plate. Actually the word "colloid" is derived from the Greek word κόλλα, meaning glue, and at the time when this term was first used by Graham it was supposed that all colloids were substances of very complex constitution, just as is glue. This, however, is by no means true, so that the meaning of the term colloid is now quite different from what it was in Graham's time. It is true that complexity of chemical constitution is likely to give rise to the colloidal state, but the converse does not necessarily hold; the elements themselves may often be obtained in so-called colloidal solution.

It may perhaps be advisable to indicate briefly what is meant by a colloidal solution. If a solution of white arsenic (arsenious acid) in water is mixed with an equal volume of an aqueous solution of hydrogen sulphide no formation of a precipitate occurs; a transparent, somewhat orange-coloured solution is obtained. Apparently it is quite a good solution, and remains as such when any excess of hydrogen sulphide has been removed by bubbling hydrogen through it. It can be filtered in the ordinary way, without leaving a residue on the filter paper and it does not settle out on keeping for quite a long time. That it is not a true solution, however, is proved by the fact that it shows the Tyndall phenomenon; if a strong beam of light is passed through the solution its path is shown up exceedingly clearly, just as the ray of light is made evident by the dust particles in the air. If water, or a solution of ordinary salt, is tested in the same way, the path of the beam of light through the solution is not visible so long as there are no suspended particles in the water or solution. The orange-coloured liquid is therefore not a true solution; it is a suspension of arsenious sulphide in such fine particles that they are not visible to the naked eye and do not readily settle out. For such a system the term "colloidal solution" is often used; it consists, however, of solid particles suspended or dispersed in a dispersion medium and a more appropriate term would be "suspensoid sol", the arsenic sulphide being a "suspensoid colloid". In most suspensoid sols the existence of the particles cannot be demonstrated by the highest power microscope, but by use of the ultra-microscope their presence can be made evident. The particles are then seen to be in rapid Brownian movement.

Compared with gelatin, arsenious sulphide is a very simple substance, but, as has already been mentioned, the simplest substances of all, namely, the elements, readily give suspensoid sols. One knows how very readily a solution of gold chloride is reduced, giving a blackish or greenish-black precipitate of gold; if, however, the reduction is carried out in very dilute solution, suspensoid sols can be obtained. To about 100 cc. of distilled water are added a few drops of a neutralised one per cent. solution of gold chloride, and then, after mixing, a few drops of a 0.1 per cent. solution of tannin. The solution is colourless, but on heating it begins gradually to take on colour and finally becomes cherry red; a red suspensoid sol of gold is then obtained. If instead of using tannin as the reducing agent, hydroxylamine is used, a violet, or blue colloidal solution is obtained, the particles of gold being larger that those in the red sol. It has been shown by the method of X-ray analysis that the particles have the same crystalline structure as massive gold.

A characteristic property of suspensoid sols is that they are readily coagulated or precipitated when solutions of electrolytes are added to them, the electrolytes used not necessarily having any chemical action on the particles of the sol. For example, solutions of hydrochloric acid, sodium chloride, magnesium sulphate, or aluminium sulphate, cause an immediate precipitate of yellow arsenious sulphide when added to the sol of that substance.

So far the colloidal solutions mentioned have consisted of solid particles suspended in a dispersion medium. Consider now, however, an emulsion such as cod-liver oil emulsion, or milk. If it is examined under a microscope it will be seen to consist of drops of one liquid suspended in another liquid. If it were possible to reduce the drops to colloidal dimensions a colloidal solution consisting of liquid particles in a liquid dispersion medium would be obtained. Such a system may be called an "emulsoid sol", and according to some chemists, especially Wo. Ostwald, gelatin gives such sols with water; other chemists, and they are in the majority, do not agree with such a structure in the case of gelatin. The question of structure, as far as we are concerned at present, is, however, a subsidiary one, since an emulsoid sol can, in general, be readily distinguished from a suspensoid sol. Suspensoid sols are practically as mobile as water itself, that is, the dispersed particles hardly alter the viscosity of the dispersion medium. On the other hand, emulsoid sols, of which gelatin is a typical example, show large viscosity values, even in comparatively low concentrations, and with increase in concentration the viscosity increases enormously, whereas there is only a small increase in the viscosity with suspensoid sols under similar conditions. Also, when a gelatin sol is cooled down it is well known that it sets to a jelly, that is, it becomes a gel, whereas no such change takes place with a suspensoid sol, such as that of gold, when treated in the same way. Moreover, the change from sol to gel is reversible, since on warming the gel it readily liquefies to a sol. Again, if the gel is dried and then immersed in water it imbibes water and swells to a greater or lesser extent.

In the case of a suspensoid it was shown that the addition of a small quantity of a salt to the sol caused precipitation or sedimentation to take place. With gelatin this only happens when large concentrations of salt are added, and not always then. It is fortunate that this is the case, otherwise gelatin could not be used as a medium in the preparation of photographic emulsions. Although precipitation does not occur the salts have a very marked effect on the viscosity, sometimes increasing, and sometimes decreasing it. For example, a 1½ per cent. sol * of gelatin, set to a gel in test tube, can be detached from the sides of the tube and broken in pieces by hard shaking. If, however, several per cent. of magnesium sulphate are added to the sol before setting, the resulting gel can be no longer broken up by shaking. On the other hand, if sufficient potassium iodide is added to the sol it will not set and remains fluid. Sulphates, citrates and phosphates act similarly to magnesium sulphate, that is, they increase the jelly strength of the gelatin, and to a much greater degree than they do that of pure water. Bromides and cyanides act similarly to iodides. Organic substances also act differently, for example, chloral hydrate and urea decrease the viscosity, whilst alcohol, in small amounts, increases it.

Similar results would be obtained if, instead of using a gel, the viscosity of the sol were measured in a viscometer. Such measurements would show, however, that further complications arise, in that there may be either an increase or a decrease in the viscosity, depending on the concentration of the added salt. For example, sodium chloride in medium concentration (about N/4) produces a viscosity which exceeds that of pure gelatin, whereas at higher or lower concentrations the viscosity is less than that of pure gelatin.

This, however, is much better shown in the case of the influence of the acids and alkalis, as is illustrated by the following figures and curves, which are due to von Schroeder. (Fig. 1.)

Conc. of HCl or NaOH	O	N/512	N/256	N/128	N/64	N/32	N/16	N/8	N/4
Rel. Viscosity (HCl)	1.40	1.55	1.76	1.68	1.58	1.42	1.25	1.17	1.12
Re. Viscosity (NaOH)	1.40	1.52	1.60	1.79	1.62	1.38	1.25	1.10	1.10

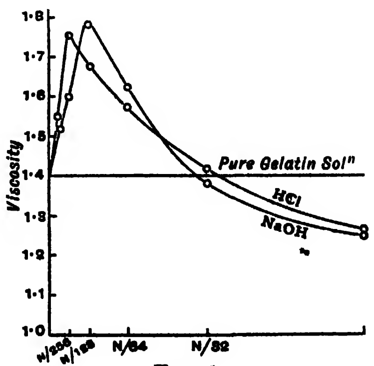

FIG. 1.

* The concentration necessary to give these results will depend on the kind of gelatin used.

It will be noticed that there is a pronounced maximum viscosity.

Similar complicated phenomena occur in connexion with the swelling of gelatin. It is well known that if a piece of leaf gelatin is put into water it takes up water and increases in volume, that is, it swells. Swelling will take place not only in water as a liquid, but also in water vapour. If a piece of thin leaf gelatin is put on a piece of filter paper and then breathed upon, it immediately bends or even curls up, showing that there is an increase in volume of the gelatin on the side which is breathed upon, that is, swelling has taken place.

The effect of various substances on the swelling may be demonstrated as follows :—A series of gelatin discs of the same size and weight are prepared by pouring a concentrated gelatin sol on a glass plate, allowing it to set, and then cutting the set gelatin into discs and drying. If separate discs are then immersed for twenty-four hours in solutions of N/20-HCl, N/20-NaOH, N/2-KI, N/5-$CaCl_2$, water, and saturated magnesium sulphate respectively, it will be noticed that the order in which swelling has been favoured is :—acid > alkali > potassium iodide > calcium chloride > water > magnesium sulphate ; the disc in the acid solution will be swollen to about twice the size of that in pure water.

The results of investigations such as those indicated led to the putting forward of what are known as the Hofmeister series, Hofmeister being the one who first studied such effects. For example the effect of equivalent (tenth normal) solutions of various acids on the swelling is indicated by the following series :—hydrochloric acid > nitric acid > acetic acid > sulphuric acid > boric acid.

With sodium salts of various acids the swelling decreases in the order :—thiocyanates > iodides > bromides > nitrates > chlorates > chlorides > acetates > tartrates > citrates > sulphates.

Such series are very difficult to understand, since the order of the compounds does not bear much relation to their ordinary properties ; it is difficult, for example, to comprehend why acetic acid comes between nitric and sulphuric acids.

It is the realisation that gelatin does not behave simply as a colloid, but has both acid and basic properties, which has brought some order out of chaos in recent years. For progress in this direction we are chiefly indebted to the work of Procter in England, Pauli in Austria, and Loeb in America.

As has been mentioned, the exact chemical constitution of gelatin is still a mystery ; it is known, however, that amino-groups ($-NH_2$) are present in the molecule, and in all probability imino-groups ($-NH-$) as well, which confer basic properties on it, and that the molecule also contains carboxyl groups ($-COOH$) which confer upon it an acid character. It is, in fact, an amphoteric substance similar in character to glycine, or aminoacetic acid, $NH_2.CH_2.COOH$, and for ordinary purposes its formula may be represented as $G\langle^{NH_2.}_{COOH.}$ where G represents the gelatin residue. If a substance behaves both as an acid and a base it is weak in both these properties, but it does not follow that its strengths as acid and base are the same. Actually these strengths are generally different and both glycine and gelatin are stronger acids than bases. Suppose now that hydrochloric acid is added to a gelatin sol ; it will combine with the amino-group of the gelatin and form the salt, gelatin hydrochloride. If the solution so obtained is electrolysed the gelatin part of the molecule, since it possesses a positive charge will travel towards the negative electrode, the cathode. If, on the other hand, sodium hydroxide is added to the solution the acid group of the gelatin enters into reaction and a sodium gelatinate is formed ; the gelatin part of the molecule is now negatively charged and on electrolysis will travel towards the positive electrode, the anode. It follows that the direction of migration of the gelatin as a whole depends on the acidity, counting alkalinity as negative acidity, of the solution. There will therefore be some point at which the acidity of the solution is such that on electrolysis the gelatin does not migrate preferentially to either electrode ; this point is called the isoelectric point, and the gelatin is said to be in the isoelectric condition. Gelatin being a stronger acid than a base, this will not be at the neutral point, where the concentration of hydrions ($H^{\cdot}$), to which acidity is due is equal to the concentration of hydroxyl ions, (OH'), which ions confer alkalinity on a solution, but at some point on the acid side of the neutral point. By experiment it has been found that in an isoelectric solution of gelatin the concentration, $C_{H^{\cdot}}$ of the hydrions is $2{\cdot}5 \times 10^{-5}$

gram-ions per litre. Another way of stating this is commonly used in the literature; the logarithm of $2 \cdot 5 \times 10^{-5}$ is $\bar{5}.39794$, or —4.60206, that is —4.6; the isoelectric point is then said to be at a value of P_H or pH =4.6. It is now commonly accepted that the isoelectric point of gelatin has a value pH=4.6—4.7*

The exact theory of amphoteric electrolytes shows that at the isoelectric point their solutions will contain a maximum number of neutral molecules and they should therefore possess peculiar properties; in accordance with this it has been found that the properties of swelling, viscosity, osmotic pressure, etc., show a minimum at that point, whilst the precipitation by alcohol is most pronounced. If to a one per cent. solution of isoelectric gelatin alcohol is added, there is an immediate precipitation; but if the solution is first acidified slightly with hydrochloric acid there is no precipitation on the addition of alcohol. Also if a one per cent. solution of isoelectric gelatin is made in the warm it is clear and transparent; on keeping at the ordinary temperature, however, the solution becomes opaque after a time and a precipitate may deposit on keeping; raising the temperature again gives a clear solution. The setting of the solution to a gel is a different process from this precipitation, since cloudiness or opacity is not connected therewith.

On the acid side of the isoelectric point (pH $<$ 4.7) gelatin should therefore behave as a base and form gelatin acid salts, whilst on the alkaline side (pH $>$ 4.7) it should act as an acid and form metal gelatinates. Loeb has endeavoured to show that this is true in several ways, of which the following, since it makes use of silver salts, may be quoted. Separate quantities of gelatin, in the form of granules, are brought to different pH's less than 7.0 by treatment with varying concentrations of nitric acid. The separate portions are then soaked for an hour in a dilute solution of silver nitrate, after which they are washed several times with ice cold water. They are then melted, diluted to the same volume in each case and portions of each put in test tubes and exposed to light, the previous manipulations having been carried out in a dark room. The pH's of the solutions remaining are determined and also the quantities of silver remaining in them. In a short time all the gelatin sols with a pH $>$ 4.7 become opaque, and then black on exposure to light, while all the solutions of pH $<$ 4.7 remain transparent, even when exposed to the light for months. The sols of pH= 4.7 become opaque, but remain white since the gelatin is isoelectric. It follows that the silver combines with the gelatin only when the pH is $>$ 4.7, that is, metal gelatinates are formed on the alkaline side of the isoelectric point. The accompanying figure (Fig.2.) is a photograph, due to Loeb, of a set of test tubes thus prepared. It should be noticed that in all cases the pH of the various solutions is on the acid side of the neutral point, pH=7

Fig. 2.

The analytical figures are given in the following table and illustrated in the lower part of Fig. 3.

The upper curve in Fig. 3. shows how the swelling of the gelatin varies with the pH, and illustrates the point to which reference has already been made, namely,

* The neutral point of water is approximately at pH=7, the exact value varying with the temperature, so that the isoelectric point of gelatin is on the acid side of the neutral point. It should be noted that with this method of nomenclature the greater the concentration of hydrions the less is the value of the pH.

c.c. 0.01N-Ag in combination with 0.25 gm gelatin at different pH's.

pH	3.6	3.7	3.9	4.1	4.3	4.6	4.7	5.0	5.3	5.7	6.1	6.4
c.c.	0.5	0.3	0.3	0.2	0.2	0.2	0.55	1.25	3.2	4.0	4.85	4.9

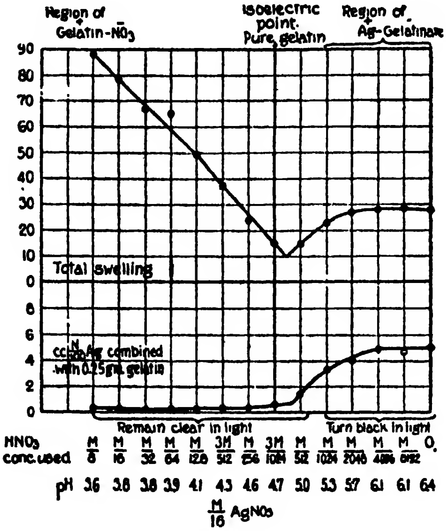

Fig. 3.

that the swelling is a minimum at the iso-electric point.

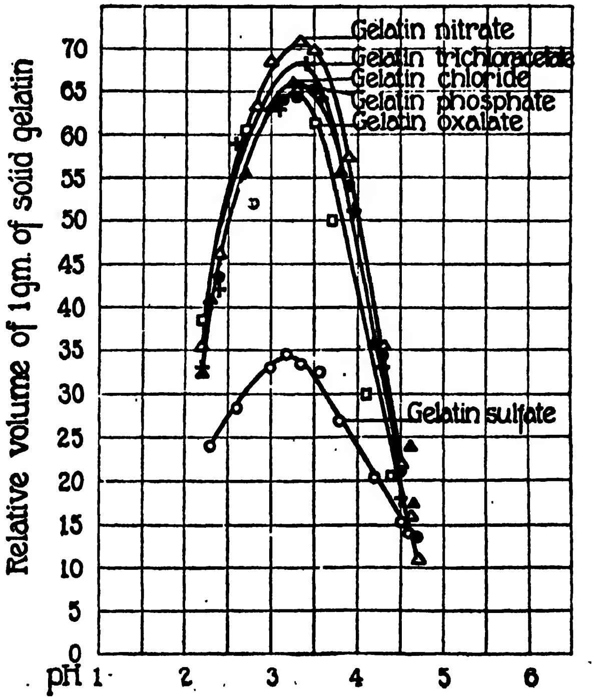

Fig. 4.

Results similar to those with silver nitrate are obtained when a nickel or a copper salt is used. With potassium ferrocyanide the gelatin retains the ferrocyanide, as gelatin ferrocyanide, on the acid side of the iso-electric point, the gelatin turning blue after a few days, owing to the formation of ferric salt. Another important result which follows from these considerations is that a basic dye is retained by gelatin on the alkaline side of the isoelectric point and is not removed by washing, whereas on the acid side the same dye is readily removed by washing. On the other hand, acid dyes are retained by gelatin when the pH is less than 4.7.

Another deduction which can be made in connexion with the pH of gelatin solutions is that if the effects on swelling, viscosity, etc., of various monobasic acids (HCl, HBr, HNO_3, $CCl_3.COOH$. etc.) and acids such as succinic, tartaric, citric and phosphoric acids, which dissociate only into two ions at ordinary dilutions, are compared at the same pH, they should be the same; dibasic acids which dissociate into three ions at ordinary dilutions, such as sulphuric acid, should give different effects. The accompanying figure (Fig. 4.) shows that within the error of experiment this is the case for swelling, and it has been shown to hold for other physical properties.

If the curves are compared with those which would be expected on the basis of the Hofmeister series, those for phosphates, oxalates, citrates, and tartrates should be in the region of the sulphate curve.

Similar results are obtained with the alkalis ; the curve for the weak base ammonium hydroxide is the same as that for the strong bases, lithium, sodium and potassium hydroxides, when plotted with pH as abscissae, whilst the curves for calcium and barium hydroxides are considerably lower.

It is obvious from the above that in processes where gelatin plays a part it is important to know the pH value. Some investigators have gone so far as to maintain that the properties of gelatin and similar substances can be completely explained by their amphoteric character and the ordinary stoichiometric chemical laws. Actually, however, there seems to be no doubt that both the amphoteric and colloidal properties must be taken into account, as will be seen now that we can proceed to consider more especially the use of gelatin in photographic processes. In the course of these considerations it will be necessary to interpolate, at times, accounts of other properties of gelatin to which, so far, reference has not been made.

It is perhaps advisable to indicate briefly how a photographic emulsion is made. An aqueous solution of potassium or ammonium bromide, to which also a small percentage of the iodide may have been added, and containing a little gelatin is warmed to a definite temperature until all the gelatin has dissolved. A solution of silver nitrate is then run in, the amount of silver nitrate being insufficient completely to precipitate the bromide ; also, the silver nitrate may, or may not, be completely converted into silver ammonia nitrate. The emulsion so obtained is heated for some time, during which it becomes more coarsely grained in character, after which sufficient gelatin is added to cause the whole to set to a stiff gel on cooling. After setting in this way the gel is shredded in a special apparatus and the shreds thoroughly washed with water until the soluble salts and ammonia have been removed. The washed shreds are then melted up again and heated at a definite temperature for some time, during which the process known as ripening takes place, that is, the grains increase in sensitivity towards the action of light. When the desired sensitivity is attained, the emulsion may be coated on plates or films, which are then dried, etc. These details are capable of almost infinite variation, according to the result which it is desired to obtain.

All gelatins, even the purest photographic gelatins, contain a certain amount of ash, due to inorganic impurities present, and one would imagine that the first thing to do would be to purify them from these extraneous constituents. Bearing in mind what has been said about isoelectric gelatin a method of purification can be readily devised, although the details of manipulation may be complicated. Ash-free gelatin has been obtained and C. R. Smith in America and Professor Luther in Germany have stated that with such a material it is impossible to get a sensitive emulsion. Smith draws the conclusion that the sensitivity of an emulsion is therefore controlled by the ash constituents, but it is early days to make such a definite statement. The processes used to remove the ash may quite possibly affect the gelatin and alter its physical properties very considerably In his experiments Luther used gelatin purified by electro-osmotic methods by the Deutsche Electro-Osmose-Gesellschaft and in a recent paper by Izaguirre in the *Kolloid Zeitschrift* it is shown that such gelatin behaves physically in a very different way from ordinary photographic gelatin. It is reasonably certain, however, that the physical properties of a gelatin do not alone confer on it its photographic properties. Emulsions have been made according to the same formula and procedure, and using gelatins of different origin but having practically the same physical properties. Microscopic examination showed that they were substantially alike as far as appearance was concerned, but actually their photographic properties were very different.

The part which gelatin plays at the actual moment of precipitation of the silver halide is probably very important, but hitherto there has been very little published on the matter. Before this can be dealt with, however, it is necessary first to refer to the influence of the concentration of reactants on the dispersity of the insoluble product formed. This can be illustrated by the following experiments :— If two very dilute solutions of ferric chloride and potassium ferrocyanide are mixed a sol of Prussian blue is obtained ; it is perfectly clear to the

naked eye. If, however, more concentrated solutions of the same compounds are used, the ordinary precipitate of Prussian blue is obtained, that is, the degree of dispersion is less, the size of particles being greater. Finally, if saturated solutions of the two salts are mixed in the proportion of two volumes of the ferrocyanide to one volume of the ferric chloride solution, the latter being poured into the former, a stiff paste is produced and the containing vessel can be inverted without losing its contents. If a little of this paste is mixed with a large volume of water it gives a clear, blue sol, similar to that obtained with dilute solutions of the reactants. It follows that when highly concentrated solutions are used the size of the insoluble particles is again decreased, that is, the dispersion is increased. That this is a fairly general phenomenon has been shown by von Weimarn, * and the following table, due to Sheppard and Trivelli, shows that it is true when equivalent aqueous solutions of silver nitrate and potassium bromide are mixed, with the formation of silver bromide.

and the results are shown in the following curves. (Fig. 5.)

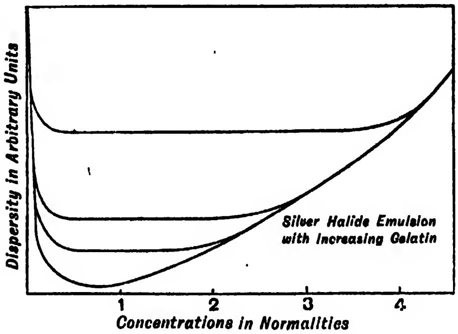

Fig. 5.

It will be seen that with increasing concentration of gelatin: (a) the range over which the initial dispersity is independent of the concentration of the reactants is increased; (b) the dispersity of the precipitated halide is increased. In other words, by varying the concentration of the gelatin it is possible to alter the grain size for one and the same quantity of silver halide.

Normality	Dispersity.	Remarks.
0.0002	Clear sol	
0.0004	Clear sol	
0.0010	Opalescent sol	
0.0025	Cloudy suspension	↑
0.025	Unstable suspension	Increasing
0.25	Flocculent → crumbly precipitate	Dispersity
0.75	Flocculent → milky above silt → curd	
1.50	Flocculent precipitate → sandy precipitate	
3.00	Curdy → crumbly precipitate	Increasing
4.50	Curdy → voluminous gel	Dispersity ↓

When the precipitation is carried out in the presence of gelatin the latter has a very marked effect; the silver bromide is obtained as a sol at concentrations of the reactants which, in pure aqueous solutions, would give a coarse-grained precipitate. This can be shown as follows:—To 20cc. of water are added two drops of 0.1-N$AgNO_3$ and the solution then divided into two halves, A and B. To A is added 1cc. of a 0.5% gelatin sol and to B 1cc. of water, after which 3 drops of 0.1-N KBr are added to each solution. B gives a thick precipitate, whilst A remains clear at first, and then becomes opalescent. Sheppard and Trivelli have investigated the matter qualitatively

* This maximum size of particles at intermediate concentrations may be a secondary effect, due to aggregation of primary particles. According to Odén the degree of dispersion of the primary particles of precipitates decreases uniformly with decrease in concentration of the reactants.

This effect of the gelatin is due to what is known as its protective action; the gelatin prevents the agglomeration of smaller particles to large ones, whereby precipitation would be produced. Zsigmondy has proposed a method of measuring the protective power in this respect of a colloid. If a solution of sodium chloride is added to a red gold sol the colour of the latter will change to blue, owing to the increase in the size of the particles; the presence of a sufficient quantity of an emulsoid will prevent this change. Zsigmondy defines as the gold number the number of milligrams of colloid just necessary to prevent 10 cc. of a standard gold sol from changing colour when 1cc. of a 10% solution of sodium chloride is added. This gold number varies considerably with different colloids; for example, it is 0.005 for gelatin, 0.01 for

casein, 0.2 for gum arabic, about 10 for dextrin, etc. Sheppard and Elliott have investigated the gold numbers of photographic gelatins, but did not find it possible to differentiate them in this manner. In this connexion it should be borne in mind, however, that the protective action of different emulsoids will vary with the nature of the suspensoid, so that the figures obtained for gold sols will not necessarily be valid for other suspensoids. Gelatin, however, seems to be the most effective protecting agent for the silver halides, as illustrated by the following experiments due to Lüppo-Cramer. To 100 cc. of a silver bromide sol (prepared by mixing very dilute solutions of silver nitrate and potassium bromide), 5 cc. of (a) water, (b) 5 per cent. dextrin solution, (c) 5 per cent. gum arabic, (d) 5 per cent. gelatin, were added. To these solutions were then added 10 cc. of a 10 per cent. solution of sodium sulphate. In case (a) the colloidal silver bromide was coagulated and precipitated immediately; in case (b) the gel formation took place after a few minutes, but sedimentation occurred after 1-2 hours; in cases (c) and (d) gel formation took place with extreme slowness.

A further complication in protective action arises from the fact that it is dependent to some extent on the coagulating electrolyte added. Thus, in the above experiments, when ammonia was used in place of sodium sulphate, the protective action of gum arabic and gelatin was very little greater than that of dextrin; albumin was found in this case to have a much greater protecting action than gelatin.

As has already been stated, the ordinary photographic emulsion in gelatin is made by taking an excess of bromide over the equivalent of the silver nitrate used. This affects the silver bromide in various ways one of which comes into play during the precipitation, and the other during the digestion of the emulsion. When silver halide is precipitated from solutions of medium concentration by a sufficient excess of the alkali halide, it settles out without the supernatant solution remaining cloudy. If the precipitate is collected on filter paper and washed, it is found that when most of the excess of soluble halide has been removed the filtrate begins to run through cloudy, owing to the formation of a hydrosol, i.e., a sol with water as dispersion medium, of the silver halide. This phenomenon takes place most readily with silver iodide and least readily with silver chloride, silver bromide occupying an intermediate position. If exactly equivalent proportions of the silver and halide solutions are used there is no formation of a sol; as already mentioned this is also the case when a large excess of the halide is used. The formation of the sol under conditions such as the above is called peptisation and is due to the adsorption or surface condensation of halide ions from the excess alkali halide, whereby a negative electric charge is given to the particles, thus conferring stability upon them.

This phenomenon is particularly interesting in the presence of gelatin, as shown by the following experiment due to Lüppo-Cramer. To 20cc. of O.3N potassium bromide solution are added 10 cc. of 0.6N silver nitrate solution; the precipitated silver bromide is collected and washed. 50 cc. of 10% gelatin solution at 50°C and 2 cc. of 10% potassium bromide solution are then added to the washed silver bromide and the whole well shaken; after 5-10 minutes a homogeneous, creamy, and almost white emulsion is obtained which can be filtered through thick flannel without leaving a residue. If the extra addition of potassium bromide is not made, the silver bromide remains suspended in larger particles, no peptisation takes place. The particles in the creamy emulsion are not sub-microscopic in size, but similar to those occurring in a lantern slide emulsion.

The influence of the gelatin is still more striking if much larger quantities of potassium bromide are added, for example, 10 times the above quantity. In the absence of gelatin the supernatant liquid over the precipitate is only slightly opalescent, whereas when gelatin is present a creamy emulsion results in a few seconds. The gelatin counteracts the coagulating effect of a large excess of bromide ions.

The peptising effect of a slight excess of bromide ions is much exceeded by that of ammonia. If 2 cc. of ammonia solution ($d=0.91$) are used instead of the 2 cc. of 10% potassium bromide in the above experiment, the silver bromide is immediately dispersed to a creamy emulsion in the gelatin.

It must be borne in mind that the peptisation of the silver bromide only takes place readily when it is freshly precipitated, that is, when it is in a condition analogous to that of a gel. On keeping for a day or so, or on boiling for 5 minutes under water,

the precipitate changes to a more stable condition, becoming more powdery and less voluminous, and it can then no longer be peptised. Also, silver bromide which has been precipitated from ammoniacal solution, or which has been precipitated in the absence of ammonia and then shaken with a dilute solution of ammonia, can no longer be dispersed in gelatin by the aid of ammonia or bromide.

The peptising effects of bromide and ammonia in the presence of gelatin at the moment when precipitation takes place are soon superseded by other effects which occur during the digestion of an emulsion. Just as silver bromide freshly precipitated from aqueous solution slowly changes from the gel to a more stable form, so does the silver bromide in the photographic emulsion change, the alteration being accelerated by the temperature of 35-40° used in digesttion. The original emulsion is practically grainless and but little sensitive to light, but during digestion it passes slowly into an emulsion in which relatively large grains are distributed more or less evenly through the gelatin. The increase in size of the grains is not due to the coalescence of smaller grains into large ones, although clumping together of grains may take place to some extent, but to the growth of relatively larger grains at the expense of smaller, the process being what is known as Ostwald ripening. Just as a small drop of liquid has a higher vapour pressure than a large one, so, below a certain limit of size, the smaller grains are more soluble than the larger ones. Now silver bromide is soluble to some extent in an excess of potassium bromide, and therefore when grains of different size occur together in the presence of this latter salt, the smaller grains will dissolve and the solute will then separate out on the larger grains. In the neighbourhood of the larger grains therefore the smaller ones will disappear and if the process is so conducted that the grains are kept *in situ*, the larger grains will become surrounded by a clear zone. This is illustrated by the accompanying microphotograph (Fig. 6.) due to Lüppo-Cramer. This effect of potassium bromide is, however, probably small in comparison with that of the ammonia which is added to the emulsion, and which is a much better solvent for silver bromide than is potassium bromide. The effect of ammonia in increasing grain size is shown

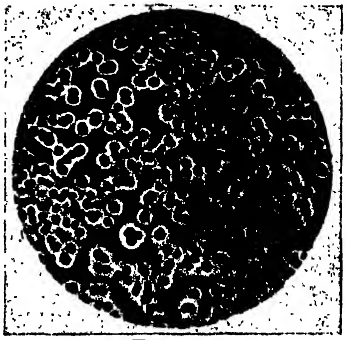

FIG. 6.

by the following experiment, due to Lüppo-Cramer: 300 cc. each of a 10% gelatin solution, the one containing 4.5 grams of potassium bromide and the other 6 grams of silver nitrate are mixed at 35° C; an almost grainless emulsion is obtained, which is clear and transparent. If, to a little of this emulsion some ammonia is added and the mixture heated to boiling, it soon goes white and cloudy, showing that a larger grain has been produced. Generally speaking, accompanying the increase in size of the grain there is a corresponding increase in sensitivity of the emulsion. At one time it was supposed that there was a definite connexion between the size of the grain and the sensitivity, but this is now known not to be necessarily the case. A high speed emulsion is prepared in a different way from one of low speed, and the latter cannot be transformed into the former by methods which increase the grain size. The increase in size may only be a concomitant factor with the one which produces speed, that is to say, in the methods used for producing high sensitivity it so happens that increase in size of the grain takes place at the same time as production of speed.

The effect of various substances on the swelling of gelatin is of importance in the process of washing the shredded emulsion in order to remove soluble salts. This is usually done with tap or spring water, both of which contain magnesium and calcium salts. Very small quantities of these have an enormous effect in repressing swelling and consequently the gel does not increase in volume to undesirable proportions. The use of distilled water would not only be very costly, but the emulsion would swell so considerably that not only would its characteristics be much altered, but the succeeding operations would have to be

very much modified. It is quite possible that when an emulsion is allowed to swell to too great an extent there may be washed out of it substances which would otherwise have an effect in the subsequent process of ripening. Hitherto, however, nothing has been published on the subject.

The extent of the swelling is also conditioned by the temperature, being favoured by an increase in temperature. It is therefore important to control the temperature during the washing process.

The amount of swelling of the washed emulsion affects its viscosity when it is melted, and also the readiness with which it sets; these properties play an important part in the coating process. At the temperature of coating, which is usually near 35-40°C, the emulsion must flow readily, so as to give an even coating on the plate, film or paper, but after the coating is complete it must also set very quickly to a firm film when cooled to a low temperature. In the first operation of emulsion making the gelatin undergoes degradation to some extent and this not only lowers the viscosity but also the readiness with which it sets. Actually, however, the gelatin used in emulsification is usually only a small fraction of the gelatin contained in the finished emulsion and hence it is the viscosity of the bulk of the gelatin used which controls the coating speed and the setting. The viscosity of a gelatin sol decreases very rapidly with rise in temperature, and evidence had accumulated in recent years that this may be due to the breakdown of a definite structure which exists to some extent even in the sol. It is probable that below 34-35°C the sol contains some gel-form, that is, gelatin molecules united to give a structure, but that above this temperature the gel-form has completely disappeared, and a very mobile liquid is obtained. This may be one reason that a temperature of 35-40° is suitable for coating; higher temperatures cannot be used since the sensitivity of the emulsion would be affected. The formation of structure in the sol has its effect on the setting point. A given gel melts at a higher temperature than that at which the sol sets (Fig. 7.) the difference in temperature being probably conditioned by the fact that the formation

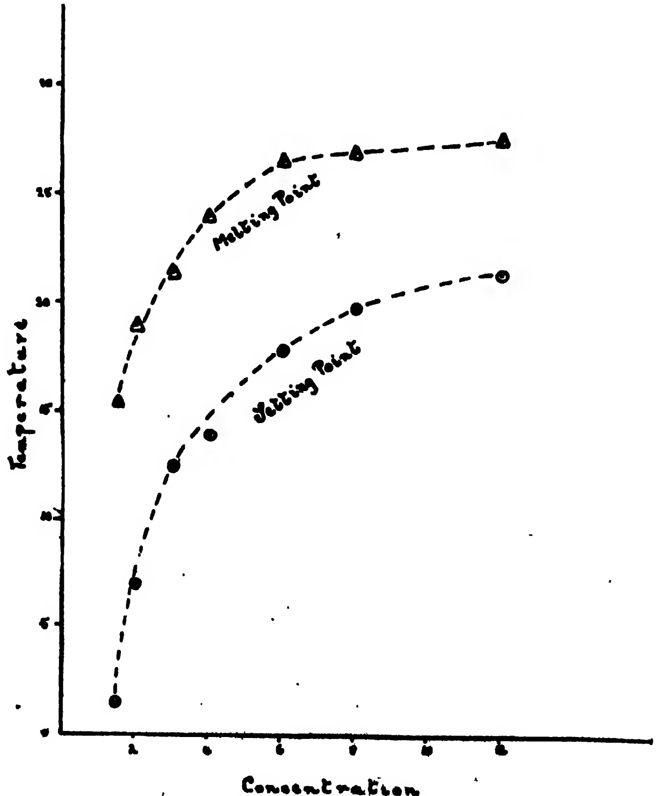

Fig. 7.

of structure takes place slowly and causes a lag in setting when the sol is cooled. Evidence for this slow building-up of structure, both in the sol and in the gel conditions has been obtained in various ways, for example, by investigations of the Tyndall phenomenon; by the change in viscosity of a sol with time, etc.

Just as is the case with other physical properties, the melting and setting points of gelatin are dependent on the content of dissolved salt, acid or alkali; they are controlled to a large extent by the pH, which must therefore always be carefully adjusted; with most photographic gelatins, however, the pH lies between 4.5 and 6.5 and between these limits there is not much variation in the properties mentioned.

The melting and setting points are raised, and the viscosity increases very rapidly, with increase in concentration of the gelatin (Fig. 7.), the rate of increase with concentration being dependent on the pH. These factors necessarily play a part in fixing the limits of concentration of gelatin between which good working results can be obtained. Actually, these limits have been arrived at by the method of trial and error, and usually lie between 6 and 7% of gelatin.

NOTES ON BOOKS.

Civil Engineering Geology. By Cyril S. Fox. London: Crosby Lockwood and Son. 18s. net.

This handsome large-octavo, with its fourteen plates and nearly a hundred illustrations in the text, is largely a study of fundamentals as regards positions for foundations, whether for vertical or oblique support; there being also a due consideration of the suitability of natural materials for constructive purposes.

Wide experiences in India enable our author to speak with personal authority as to many of the less known aspects of the earth's crust, also to depict and study extreme examples of such conditions as ordinarily affect building and civil engineering in other countries: thus casting new and vivid lights on everyday practice.

The frontispiece, for example, represents a wonderful folding of strata in which we see the border of a reverse fold as it outcrops on a high ridge in a wild and rocky region of Afghanistan: the outcrop appearing almost like the edge of an Elizabethan collar or ruff. Turning now to pages 15, 16 and 47, the reader will find scheme-drawings of comparable folded strata in more modest dimensions and in more everyday aspects; while on pages 44-46 Mr. Fox shows how such strata may impose a shearing or twisting stress on a tunnel or other work passing through, especially when the infiltration of water steps in as a factor.

Part I of the work consists of five chapters, embodying the various aspects in which the civil engineer or builder must study water, whether as a serviceable material in relation to work, or as an uncertain and insidious foe in relation to underground matters. It is instructive to study our author's infiltration diagram on page 20, and his demonstrations as to the influence of stratum-faults on artesian conditions (pp. 24-25); while his account of water difficulties overcome by the genius of Robert Stephenson when constructing the Kilsby tunnel near Rugby, followed by an abstract of Baldwin-Wiseman's teachings on pressure and porosity (p. 30), well illustrate the thoroughness of the book.

We hear much as to the instability of buildings in London owing to the slip of water-lubricated strata, and although the alarmist stories as to St. Paul's may have no firm basis, in fact, there can be no doubt as to the state of Waterloo Bridge: probably owing to the scouring away of the lateral support of the foundations by the deepened and constricted stream. The thorough consideration of water matters by Mr. Fox rather suggests that the engineers of our day may well consider whether the time has come for a fundamental change as regards substructure, in the case of the more important new bridges. Gwilt, on p. 513 of his Encyclopædia of Architecture (Longmans, 1842) shows the inverted arch foundation suggested by "Our Master" Leo Battista Alberti, and on p. 134 Gwilt says that Alberti's book *De Re Edificatoria* "is the foundation of all that has been since written on the art." If this principle were put into practice in conjunction with modern methods of tunnelling the result would be a bridge nearly symmetrical above and below, and probably resting on a broader beam or bed of reinforced concrete: this beam having a bore or passage for observations on strain and flexion. It is interesting to note that Gwilt (p. 512) suggests the reinforcement of concrete foundations with embedded iron.

In a review it is not practicable to give an adequate idea of the full scope, detail or contents of a work like that now before us; but this valuable addition to technical literature seems to be equally suitable for use as a first book by the architectural student or as suggestive reading for the matured practitioner.

THE ST. ETIENNE RIBBON INDUSTRY.

Long before the industrial city of St. Etienne was noted for its production of coal and iron, it was known as one of the chief ribbon markets of the world. The beginnings in the 16th century were small. About 1680 the number of handlooms increased from 700 to 10,000 and the industry was very prosperous. In less than a hundred years, however, foreign competition had greatly crippled it, for Switzerland and Austria had begun to

utilise mechanical looms which turned out 30 pieces of ribbon at a time. Several St. Etienne manufacturers then brought over some Swiss looms, and soon regained the lost preponderance. Later, the invention of the Jacquard loom occasioned another era of great prosperity. The number of manufacturers increased to 190, and has remained at about this figure.

Toward the end of the 19th century an event of great importance was the installation of electric motors in factories and in the homes of the weavers. At present, 12,360 home looms are operated by electricity, as compared with 6,604 in 1900.

From a recent report by the United States Consul at St. Etienne it appears that practically everything that the ribbon trade can offer is manufactured there, including a series of articles always in vogue, used by confectioners and needlework shops, and also ribbon for lingerie, corsets, shoes, garters, men's hats and suspenders, and other purposes. Recently, since the commodity has been less in vogue, the manufacturers have devoted themselves to the production of silk piece-goods and other silk products, which Lyons has always more or less monopolised. Now, in novelty silks, St. Etienne begins to rival that city, because of its long experience in combining designs and colours.

The aggregate production value of silk and velvet ribbons and silk piece-goods during 1923 increased by 83,948,755 francs, as compared with the figures for 1922, according to statistics issued by the Ribbon Manufacturers' Association of St. Etienne. One of the notable features of the industry was the large increase in the employment of artificial silk in the manufacture of ribbons and silk piece-goods. Among items showing outstanding increases in production compared with 1922 were articles made of artificial silk, 21,820,190 francs; fancy ribbons, pure silk and mixed, 23,502,737 francs; and articles made of cotton, 8,201,173 francs. The total value of the production in 1923 is estimated at 378,182,694 francs, and the value of the home consumption is given as 226,952,412 francs.

The direct exports of ribbons during the year were valued at 151,230,280 francs.

THE LACE INDUSTRY OF TONKIN.

The lace industry in Indo-China is only 20 years old. It was introduced by the French and to-day is centred in Tonkin, although the natives of Cochin-China, Laos, and Annam are beginning to produce for local consumption.

According to a report by the United States Consul at Saigon, it is estimated that 4,000 Tonkinese—men, women, and children—are engaged in the manufacture of lace. Hanoi is the centre of the industry, and it is there that European export houses procure their supplies. The industry was started, and has been fostered, by the French. All the designs and styles of lace are furnished by the export houses, the natives having none of their own. The laces manufactured in the villages are either sold in the hotels and cafés or used locally. All the lace exported to France is made to order. The various kinds of lace manufactured in Tonkin for the export houses are: Craponna, Cluny, Venice, Irish, and embroideries on filet of linen thread or of cotton meche. The filet laces are particularly popular on the French market, the other kinds not being produced so successfully. Thus, far, the natives have not been instructed in making Bruges or Valenciennes laces.

It is difficult to determine the importance of the industry, as the greater part of the exports are taken by tourists or sent out of the country by parcel post. However, the Customs declare that the value of the lace sent from Tonkin to France by steamer in 1922 amounted to 2,835,000 francs. It is estimated that the value of the lace taken out of the country in other ways amounted to an equal figure. It would seem, therefore, that the industry, in approaching an annual export value of 6,000,000 francs, is becoming an enterprise of some importance. Furthermore, considering the abundance of cheap labour existing in Tonkin, and the fact that cotton and silk are also produced in the country, it may assume still greater proportions.

THE IMATRA (FINLAND) POWER SCHEME.

In his annual report on the commerce and shipping of Wiborg, the British Vice-Consul at that port remarks that the only undertaking in the district that merits notice is that of the power station at Imatra, which is regarded as of national importance. The scheme had its inception in 1900 and took form in the ensuing decade in the course of which a committee was appointed to consider its possibilties. The war put an abrupt end to any prospect of work and, after Finland had gained her independence, a scheme of wider scope, developed at the instance of the Finnish Government, was accepted by the Diet in 1921. This is a far-seeing plan which permits of subsequent expansion as requirements demand. The initial part of the scheme provides for three sets of machinery of a combined 73,000 turbine h.p. or its equivalent of 49,000 high tension kilowatts. The outlay, based on the Government index figure of the cost of living, is estimated at 3,350 marks per one high tension kilowatt or 170 million marks for the early part of the scheme.

The Imatra Rapids can produce 117,000 h.p. and those above at Linnankoski 33,000 h.p. at average water level. When all this latent power is available, 100,000 high tension kilowatts would be employed, and it is calculated that by then the average expenditure will have been reduced to 2,800 F. mks. per high tension kilowatt.

The project provides for the laying down of a main power cable to Wiborg. A second would go to Villmanstrand, thence to Riihimäki, and on to Helsingfors, Abo and Karja. A transmission tension of 110,000 volts would be used. Sub-power stations for distribution are to be erected at

points where the current would be most in demand.

The central idea is to harness and bring under one control the electric energy dormant or already developed in the three principal rivers of the south of Finland; the Vuoksi, the Kymi and the Kokemaki. Any existing plant would be brought up to date and it is thought that now is the most favourable time for merging any power stations on these three rivers into the Imatra Scheme.

The supply of this electric motive power will, it is anticipated, effect a considerable economy in fuel expenses, promote trade and assist the more rapid development of the resources of the south of Finland. It is expected that manufacturers will be the main support of the undertaking and that it will yield an adequate return on capital from the outset.

The Finnish Government intend to reserve to the State the full rights over the exploitation of the Imatra Rapids and any others that may be amalgamated with the Imatra Scheme.

The work done at an expenditure of 16 million F. mks. towards the realisation of the scheme in 1923 included the removal of 195,000 cubic metres of earth and rock, of which 150,000 cubic metres were employed to make an embankment. A temporary dam was thrown across half the width of the falls to aid the later erection of a permanent concrete structure. Accommodation for engineers and labourers was provided and 11 kilometres of narrow gauge railway laid down. 450 men are at present engaged. The work is planned for completion in 1927.

PROJECTED DEVELOPMENT OF DUTCH NEW GUINEA.

The opening up of Dutch New Guinea for future colonisation and development of natural resources is contemplated by a large German-Dutch company, recently formed. The Dutch portion of the island covers about 152,000 square miles, of which approximately 77,220 square miles are to be allotted to the new company for a period of 75 years, with the exclusive right to obtain forest, agricultural, mineral, and sea products. The native population of the whole of Dutch New Guinea, however, is to retain its unrestricted right to collect and sell similar products. From reports furnished by the United States Vice-Consul at Soerabaya and by the U.S. Trade Commissioner's office at The Hague, it appears that the company is to be granted a right of preference for leasing land in accordance with the stipulations in force, and preferential rights to licenses for prospecting and developing minerals in accordance with the mining regulations of the Netherlands East Indies.

Owing to the sparse population of New Guinea the labour question is one of the utmost importance. The company is privileged to effect working agreements with the natives, as well as with foreigners whom it may take into its service—possibly Chinese coolies. It has also been suggested that labourers for the cultivation of coconuts will be brought from Japan and the Molucca Islands.

In return for the privileges requested, the company is to pay to the autonomous government of the district fixed excise duties and 10 per cent. of its net profits to the Government of the Netherlands East Indies. It is also to defray the expenses of police protection.

COCA CULTIVATION IN THE NETHERLANDS EAST INDIES.

The cultivation of the coca shrub a few years ago was regarded as one of the most promising industries in the Netherlands East Indies. In 1919 the total area planted reached 7,980 acres. Coca is usually grown among other crops, and, therefore, writes the United States Consul at Batavia, it is difficult to determine the exact area under cultivation. Official statistics, moreover, do not agree as to the number of estates on which this plant is grown. In 1921 an area of 2,998 acres was reported for 16 estates and 29 had coca planted alongside the roads, according to the annual statement of the Department of Agriculture, Industry, and Commerce.

The acreage planted to growing shrubs, the reported production, and the quantities exported during the period 1918 to 1922, inclusive, as stated by the Bureau of Statistics, were as follows:—

Years	Planted area	Reported production	Exports
	Acres	*Pounds*	*Pounds*
1918	6,958	2,549,476	1,456,329
1919	7,980	1,687,591	2,187,247
1920	6,308	1,805,186	3,688,567
1921	2,998	1,599,728	2,502,221
1922	3,512	1,960,717	2,823,707
Total ..		9,602,698	12,658,071

The preceding figures, of course, apply to the dried leaves, and it is apparent that there is considerable production from areas not reported. The production of the "catch crop," planted in single rows along the edges of fields of other crops, is also not reported to the Bureau of Statistics, but the difference between the production of estates where cultivation is carried on in a systematic manner and the exports—amounting to about 3,000,000 pounds during the five years—represents the quantity produced in this manner.

The 1923 exports of coca leaves were some 2,066,000 pounds, according to preliminary figures. The Netherlands was the leading destination in that year, receiving 1,187,400 pounds, compared with 1,987,000 in 1922. Japan came second, with about 800,000 pounds in 1923. The Netherlands is the distributing point for Europe and also probably for a large part of the trade of the United States. The figures for Japan, accounting for more than one-third of the total, indicate that it is one of the leading manufacturers of the drug. No cocaine in manufactured in the Netherlands East Indies.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICE.

INDUSTRIAL DESIGNS COMPETITION.

In accordance with the desire expressed by the Queen on the occasion of her visit to the Society's recent exhibition of Industrial Designs at the Victoria and Albert Museum, Her Majesty has purchased a design exhibited by Mr. William R. Pearson, of Leicester, in the competition for the prizes offered by Messrs. J. S. Fry & Sons, Ltd., for chocolate box designs. Another exhibit of this competitor was awarded a prize given by the same firm in a different class.

PROCEEDINGS OF THE SOCIETY.

COBB LECTURES.

CERTAIN FUNDAMENTAL PROBLEMS IN PHOTOGRAPHY.

By T. Slater Price, O.B.E., D.Sc., F.I.C., F.R.S.

(Director of Research to the British Photographic Research Association).

Lecture II.—*Delivered March* 31*st*, 1924.

The method of drying the coated plate is very important; it must be done under uniform and standard conditions, since it is a well-known fact that during the drying of coated plates a further ripening takes place. Comparatively little work has been published on the drying-down of gelatin gels; it is a question which is intimately bound up with the structure of such gels, and in the case of photographic plates there is the further complication that the gel tends to dry down (and swell up) normally to the surface. The drying-down is, however, not absolutely normal to the surface, and Sheppard, Elliott and Sweet have investigated the lateral contraction which takes place when a gelatin gel is dried down on a rigid support, by using thin aluminium sheet as the support and measuring the curvature of the same after drying to equilibrium with an atmosphere of fixed humidity at a definite temperature. The contraction occurring was found to vary with the origin of the gelatin, such variations possibly being connected with different structures; it was also found to be dependent on the initial pH of the gelatin, being greatest in the neighbourhood of the isoelectric point. Over the range of pH usual for photographic gelatins there was not much variation.

The reverse process to drying-down, namely, swelling, takes place during the operations of development, fixing, and washing. It is the readiness with which gelatin swells and thereby becomes permeable to aqueous solutions which makes it so useful as a vehicle in sensitive emulsions. The swelling must be controlled, however, otherwise such troubles as frilling occur and the gelatin film is liable to come away from the support. It has already been pointed out that dissolved salts, etc., have a very marked influence on the swelling, so that fortunately methods of control are in the hands of the photographer; also, as we shall see, further control can be exerted by hardening the film. One curious fact about swelling is that it depends very much on the previous history of the gel. Bancroft has instanced the following: "Gelatin gels were made containing 8, 16, 24 and 32 per cent. of gelatin; these were all dried at room temperature to about 96 per cent. concentration. When water was added, each swelled rapidly to the original concentration and then took up water slowly. If these results are accurate, it means that the four 96 per cent. gels were all different and that the 8 per cent. gel did not become like the 16, 24, or 32 per cent. gel while being dried." It has been a controversial point as to whether this phenomenon was due to a skin effect or to differences in internal structure, but recently Gortner has brought definite evidence in favour of the internal structure explanation. He finds that if

jellies of different initial concentrations are dried, powdered, and swollen in water again, the swelling limit still appears to depend on the initial concentration.

The pioneers of scientific measurements in photography, Messrs. Hurter and Driffield, early studied the swelling of the film on plates, but, using modern methods, Sheppard and his co-workers have recently investigated the problem more carefully. Solutions of ordinary developers, such as pyro, hydroquinone, etc. are alkaline, and, as has already been pointed out, alkalinity increases the swelling of gelatin to such an extent that very undesirable results would accrue were no other substances present to check the swelling. Sodium carbonate is usually the alkaline component of developing solutions, however, and as the following figure (Fig. 8.) shows, when present in 5 per cent. concentration or more it depresses the swelling to a value below that which obtains in water.

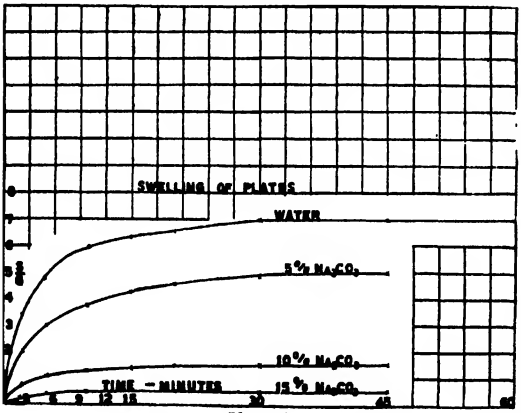


FIG. 8.

Sodium sulphite has an effect similar to that of sodium carbonate, as shown in Fig 9. The same figure shows the effect of each of these in the presence of pyro.

The curves in Figure 9 show that a fairly stationary value of the equilibrium is soon attained, and also that the depressing effect of the salts increases very rapidly with increase in concentration. The latter fact may be made use of in preparing developers for use at high temperatures, as in the tropics.

It should be mentioned that results obtained with the free swelling of gelatin cannot be transferred quantitatively to the swelling when the gelatin is fixed on a rigid support. In the latter case the maximum swelling tends to be considerably

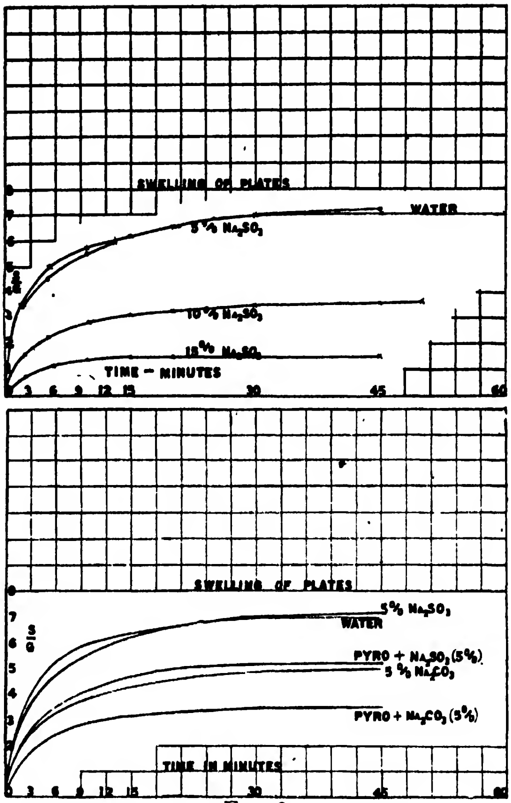


FIG. 9.

less, at the same temperature and pH, than in the former case.

Another method of preventing the swelling which takes place at the high temperatures of the tropics is to harden the film before development. For this purpose formaldehyde is a common reagent, which may also be used in conjunction with anti-swelling salts. For example, in a method patented by Ilford Ltd., the formaldehyde solution contains also a salt such as sodium citrate, sodium sulphate, or magnesium sulphate, which, as mentioned previously, depress the swelling of the gelatin. The gelatin is hardened by the formaldehyde because of the formation of an insoluble condensation product. The action is not instantaneous, but increases rapidly with time, and is all the more pronounced the less swollen the gelatin. The beneficial effect of the added salts is, therefore, probably due to the effect they have in preventing the swelling of the film before the formaldehyde exerts its full action.

The prevention of swelling is very important, not only for obviating frilling, which, when very pronounced may lead to the

gelatin film floating off its support, but also for stopping reticulation. When the swelling pressure becomes very great the increase in volume normal to the support may not be able to account for it all; lateral or tangential dilation will then take place and if the attachment to the support remains firm the film will pucker or reticulate. Reticulation may give a mosaic effect and is particularly marked after short treatment with a hardening agent, followed by warm water. (Fig 10.)

The valleys of the reticulations are hardened, whilst the ridges are softer and

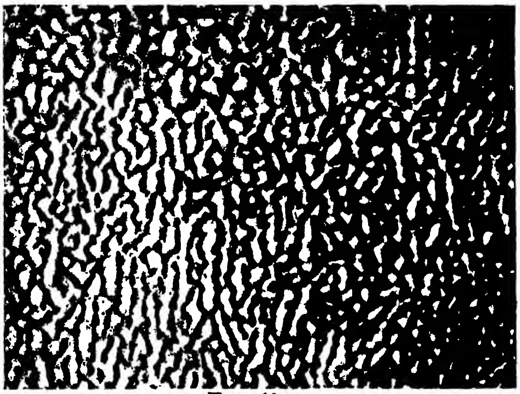


FIG. 10.

more swollen; at the same time the latter draw the silver particles into them to some extent, so that the appearance of an image is spoiled.

After development the plate is rinsed and then fixed, which is now often carried out in an acid fixing bath. Since the developer is alkaline, this means that the gelatin must pass through the isoelectric point, where the swelling is a minimum, to some point on the acid side, where the swelling again becomes noticeable. Before dealing with the complication of the acid fixing bath, however, it will be as well to consider the processes which take place when an ordinary fixing bath is used, that is, one containing sodium thiosulphate only. In the first place the time taken for fixation will depend on the rate at which the thiosulphate diffuses into, and dissolves silver halide out of, the film. This is well shown by fixing plates in one case suspended face down, and in the other face up, without stirring or rocking. The face-down plates will be fixed in approximately half the time required for the others. This result with the face-down plate is probably dependent on the down-flow of the heavy reaction products causing convection currents at the surface of the plate, whereby fresh thiosulphate is continuously supplied: this particular effect may be left out of consideration in what follows. The rate of diffusion of the thiosulphate into the film for a given amount of swelling of the gelatin would be all the greater the higher its concentration; also the more swollen the gelatin the more readily will the thiosulphate diffuse into it. Increase in concentration of the thiosulphate however, decreases the swelling of the gelatin, as shown by the sloping curve in (Fig. 11.). There will come a point,

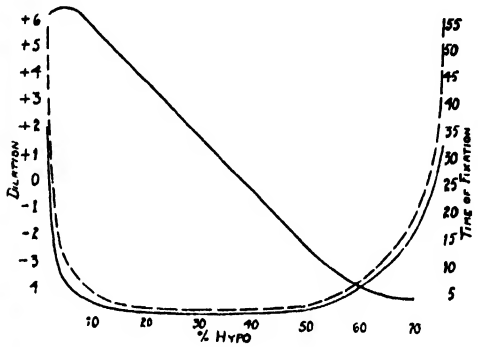


FIG. 11.

therefore, when the effect of the diminished swelling more than counterbalances the effect due to increased concentration of the thiosulphate, that is, there will be a minimum time of fixation. That this is the case is shown by the following curves, (Fig. 12.) due to Sheppard, which indicate that this minimum time is at a concentration of about 30-40% of thiosulphate, a result which had previously been obtained by Welborne Piper, among others. The influence of rise in temperature is also shown by the curves, there evidently being a double effect, namely, increase in rate of diffusion of the thiosulphate and increasing swelling of the gelatin. The effect due to increased swelling may be illustrated by the acceleration of fixing produced by adding to the bath such substances as ammonia or ammonium thiocyanate which increase the swelling of the gelatin; these substances are, however, likely to cause trouble owing to the softening effect they have on the gelatin.

We may now consider the acid fixing bath, the constituents of which are: sodium thiosulphate for dissolving the silver halide; sulphurous acid or some organic acid, which acts as a clearing agent, reduces stain and promotes swelling; sodium sul-

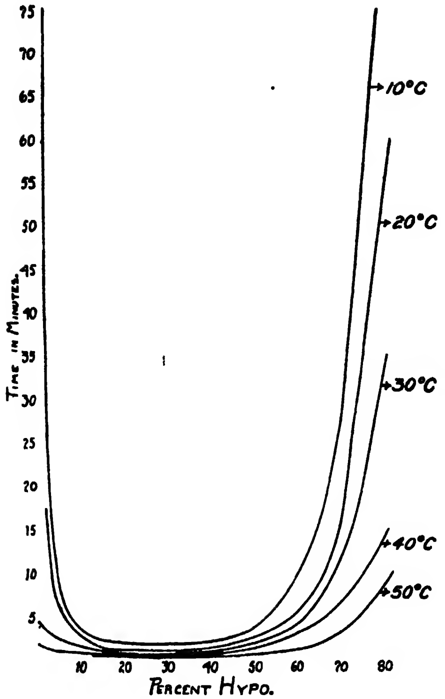


FIG. 12.

phite or meta-bisulphite, which protects the thiosulphate against decomposition by the acid, and also prevents oxidation and hence staining; alum, which hardens the gelatin and prevents frilling, etc.

It will be convenient first to deal with the action of alum as a hardening or tanning agent. It has already been pointed out that concentrated solutions of many salts suppress to a greater or lesser extent the swelling of gelatin. In this sense they may be called hardening agents, but the hardening effect is only temporary, since it is only in action in the presence of these salts and disappears when the gelatin is soaked in water. When such substances as alum are used, however, the hardening is permanent in the sense that it is not reversed by subsequent washing; the gelatin takes up some substance and becomes insoluble.

The explanation of the action of the alums, with which salts may also be classed those of heavy metals, is at first sight, fairly straightforward. It is based on the fact that such salts are hydrolysed in aqueous solution, hydroxide of the metal being formed and acid set free, as, for example, in the case of ferric chloride.

$$FeCl_3 + 3H_2O \rightleftarrows Fe(OH)_3 + 3HCl.$$

The hydroxide remains in colloidal solution. Hydrolysis being a mass action, it will be increased by dilution of the solution. It is also increased by rise in temperature, as may be shown by the following experiment. A solution of ferric chloride is diluted so that it possesses very little colour, and then divided into two parts. On boiling the one part it becomes very much darker in colour, owing to the colloidal ferric hydroxide formed by hydrolysis.

The increased hydrolysis, on dilution, may be shown by the following experiment due to Lüppo-Cramer. A solution of ferric chloride is diluted with a one per cent. sol of gelatin, when it is seen to assume the same dark colour as the aqueous solution does on boiling, showing the increased hydrolysis. Strictly speaking, however, this is not merely the effect of dilution; the colloidal ferric hydroxide is adsorbed by the gelatin, forming a complex of some kind and thus the equilibrium represented by the equation already given is disturbed and more hydrolysis takes place; there is, therefore, the double effect of the dilution and of the influence of the gelatin.

All ferric salts are hydrolysed in aqueous solution in a similar way to ferric chloride; the same is true of aluminium and chromium salts, and it is with these last-mentioned salts especially that Lumière and Seyewetz have carried out quantitative measurements. They determined the quantities of the sulphate, chloride, nitrate and acetate of chromium respectively which were necessary to render a given amount of gelatin insoluble. When the weights of chromium hydroxide equivalent to each of these quantities of the different salts were calculated, it was found that they were approximately the same. One is, therefore, justified in concluding that it is the chromium hydroxide, formed by hydrolysis, which makes the gelatin insoluble, owing to the formation of a complex of some kind with the gelatin. The acid set free by hydrolysis can be washed out, leaving the hardened gelatin. Treatment of the hardened gelatin with small quantities of acid or alkali will dissolve the chromium hydroxide and the gelatin, then readily swells and dissolves in water. In a similar way it has been shown that the hardening produced by aluminium and ferric salts is due to the hydroxides formed by hydrolysis.

In the above no definite statement has been made as to the actual cause of the

hardening of gelatin by such a salt as alum, beyond saying that it is possibly due to the formation of a complex of some kind between the metal hydroxide and the gelatin. According to Loeb, gelatin only combines with metals when its pH is greater than 4.7, and one would therefore conclude that for an alum hardening bath to function properly the acidity of the solution must lie between pH 4.7 and the neutral point, pH 7, between which values an aluminium gelatinate could be formed. The difficulty immediately arises, however, that the pH of a solution of an aluminium salt, say M/10 aluminium chloride or sulphate, is somewhere between 2 and 3. At a pH of 4.7 or more a large proportion of the aluminium would have been precipitated as hydroxide; in fact, results obtained in experiments on the addition of sodium hydroxide to the solution of an aluminium salt indicate that the formation of the hydroxide commences at pH 3 and is complete at pH 7, beyond which the alumina goes into solution as aluminate. Visible precipitation of the hydroxide may not take place until one-third to one-half of the alkali necessary for complete precipitation has been added, but evidence has accumulated that between the limits pH 3 and pH 7 the formation of intermediate complexes takes place, which, with aluminium chloride would pass through stages such as :- $Al(OH)Cl_2$, $Al(OH)_2Cl$, $2Al(OH)_3$, $Al(OH)_2Cl$, etc. There is thus the formation of complex positive ions and the question arises as to whether these may have a hardening effect on gelatin at a pH less than 4.7. The following curves (Fig. 13.) show that such hardening, as measured by the melting point of the gelatin, does take place, the maximum hardening occurring in the neighbourhood of pH 4.0. According to Loeb's ideas this would necessitate the existence of negative gelatin ions at a pH less than that corresponding with the isoelectric point.

It will be seen that a true explanation of the hardening action of alum on gelatin has still to be found. The reaction is really a complicated one and it does not seem probable that Loeb's ideas can be applied without considerable modification. If it is granted that some complex is formed between the aluminium hydroxide, or basic hydroxide, and the gelatin, the latter acting as a regulator of the hydrolysis, the nature of the complex still remains a mystery.

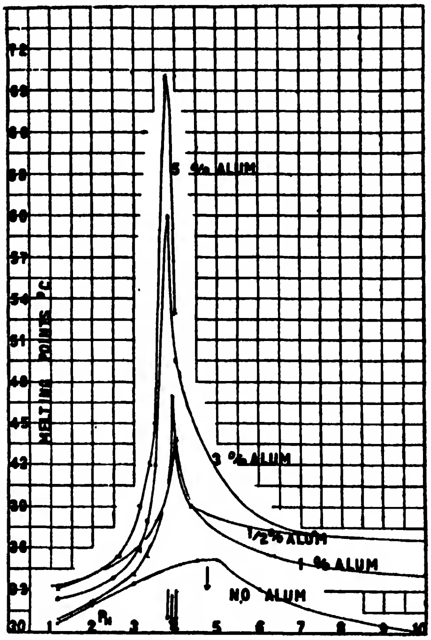


FIG. 13.

Returning now to the acid fixing bath, its acidity generally lies somewhere between pH 4 and pH 5, that is, near to the point of maximum hardening, pH 4, mentioned above. The optimum acidity, however, is not dependent only on the alum, but also on the thiosulphate present. Acids decompose thiosulphate with the liberation of sulphur, as expressed by the equation :—

$$S_2O_3'' + 4^{\bullet} \rightleftharpoons HSO_3' + S.$$

This reaction is represented as reversible and experiment shows that the addition of sulphite, or of metabisulphite, $Na_2S_2O_5$, has a retarding effect on the liberation of sulphur. The exact effect of the sulphite is, however, probably very complicated owing to the formation of salts of the various polythionic acids. Now in the acid fixing bath the pH cannot be much less than 4, otherwise sulphur will be precipitated. For the alum to have its hardening effect, however, the pH must not be greater than about 4, otherwise aluminium hydroxide will be precipitated and the bath will be useless. There thus seem to be two demands which will be very difficult to satisfy at one and the same time, owing to the narrow limits of pH allowable, but this difficulty is overcome by using such organic acids as citric, tartaric, etc., to give the necessary acidity. These give rise to the formation of complexes with aluminium and thus prevent the deposition of

aluminium hydroxide, but at the same time a further complication is introduced in that the complexes decrease the hardening action of the alum, as shown in the following (Fig. 14.). Too much organic acid must, therefore, not be used.

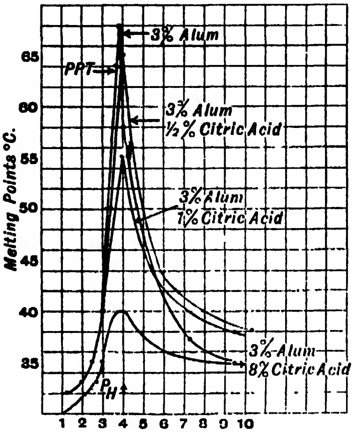
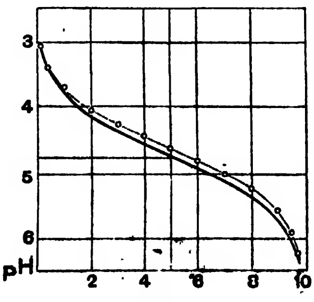


FIG. 14.

The sulphite and thiosulphate present in the bath also alter the pH of the maximum hardening effected by the alum, raising it to values equal to or greater than 4.7.

One other point has still to be considered. The acid fixing bath must have a reasonable reserve acidity in order to neutralise alkali left in the gelatin film after development and rinsing with water; at the same time there is the condition that the pH of the solution must not alter much as this acidity is used up. The acid is also necessary to transform coloured products from the developing solution into colourless acids, so as to remove stain. Such reserve acidity is always attained when, as in the acid fixing bath, there are present a weak acid and its sodium salt. The nature of the phenomenon may be illustrated by the following Fig. 15, which shows how the



cc. NaOH

FIG. 15.

pH of solutions of acetic acid varies as increasing quantities of sodium hydroxide are added to it, 10 cc. of the hydroxide being equivalent to the acetic acid taken. It will be seen that between 2 cc. and 8 cc. of added sodium hydroxide the rate of variation of the pH is comparatively small, varying between 4.05 and 5.23. After this point the variation becomes very rapid and the acidity rapidly diminishes with added alkali. Thus a solution corresponding with pH 4.05 can have its acid neutralised to a very considerable extent before its pH changes appreciably.

From the above it will be seen that the action of the acid fixing bath is a very complicated one, and although it was introduced by Lainer in 1889, and made up empirically, its exact action still awaits explanation. A compromise has to be made between the various requirements and this compromise results, to some extent, in a diminution in the hardening effect of the alum. Where satisfactory hardening is required it is best to use a separate hardening bath.

Naturally the removal of excess thiosulphate, etc. from the fixed plate by washing with water is affected by the swelling of the gelatin and hence by the hardening. The process is one of diffusion, consequently the method of bringing the plate into contact with the washing water and of renewal of the latter is of very great importance. Want of space, prevents however, discussion of this question.

It is now necessary to give some discussion of the part which gelatin plays in the process of development, and also in the grain itself. In the first place, however, reference must be made to the reduction of silver halides, especially the bromide, in the absence of a medium. For a long time there was considerable controversy as to whether medium-free silver bromide was not instantaneously reduced by a developer. The question was settled, however, when several different observers showed that it was possible to prepare medium-free plates from silver bromide precipitated from aqueous solutions in the dark, and, after exposure, to develop them with suitably restrained developers and obtain an image. The production of an image indicated that the unexposed silver bromide was not reduced by the developer in the time necessary to reduce the exposed halide.

The divergent results which were first

obtained by different investigators were probably due to differences in the silver bromide used, as is indicated by the following experiments of Lüppo-Cramer. 400 cc. of 3/200-N silver nitrate were added, in non-actinic light, to 400 cc. of an equivalent solution of potassium bromide, whereby an opalescent sol of silver bromide was obtained. When 10 cc. of a metol-soda developer were added to 200 cc. of the fresh sol, reduction to silver was only noticeable after 10-15 minutes, and after that time proceeded only very slowly. If, however, the sol had been exposed to daylight for a few seconds, the addition of the developer apparently brought about instantaneous reduction. Further, if electrolytes were first added to the unexposed sol in order to decrease the dispersity, reduction took place within a few seconds of adding the developer, whilst a sol which had been kept for three or four days and had partly precipitated was reduced immediately. Schumann, in experiments on so-called grainless emulsions, had also found that the coarser the precipitate of medium-free silver bromide, the more readily it was reduced.

The fact that the fresh sol is not so easily reduced as one which has aged to some extent is an anomaly in itself. The more finely divided a precipitate is the greater is its surface energy and consequent reactivity, so that one would expect the fresh sol to be more readily reduced. Also, a freshly formed precipitate is often in a metastable condition and much more reactive than when it has changed to the stable condition. It is possible that the phenomenon is affected by adsorption reactions, and it would be worth while to repeat the experiments under strict conditions. It is interesting to note that according to Weisz, silver bromide precipitated from aqueous solution is more sensitive to light the finer the grain.

In contrast with the medium-free compound there is no doubt as to the retarding effect of gelatin on the reduction of silver bromide, since it is this effect which has made the gelatin photographic emulsion a possibility. Various instances could be given to show that the viscosity of the medium has an influence on chemical reactions, and at one time, as especially instanced in the older literature, it was supposed that it was due to some mechanical influence of the gelatin that the reduction of unexposed silver bromide was prevented in its presence. Such an explanation cannot, of itself, be sufficient, however, since it has been found that quantities of material insufficient appreciably to affect the viscosity of water produce a pronounced retardation. Thus Reinders and Nieuwenburg found that the rate of reduction of finely crystalline silver chloride by ferrous citrate was appreciably retarded even in the presence of 0.001% of gelatin; retardation was also observed in the presence of certain dyes which in themselves, would have no effect on the viscosity of the solution.

It is, of course, possible that in the presence of gelatin the rate of solution of the grain may be considerably retarded, and this would slow down reduction. This, however, would not explain why the exposed grain which has undergone no visible change reduces so readily. Moreover, Reinders and Nieuwenburg showed that the velocity of solution of silver chloride in ammonia is not altered in the presence of 0.2% of gelatin. In this connexion, however, it should be pointed out that Peskoff has shown recently that gelatin has an enormous influence on the rate of solution by potassium hydroxide of such colloids as arsenic sulphide and also that it affects the rate at which secondary aggregations are broken down into primary particles.

There is, however, another way in which gelatin can have an effect. It has been shown by Marc that colloids, including dyes, cause a very marked retardation of the rate of crystallisation of supersaturated solutions. When the reduction of silver bromide by the developer takes place the silver first formed will be in solution or in the form of amicrons—particles smaller than can be observed in the ultramicroscope. If nuclei of silver are already present in the grain, as is supposed to be the case after it has been exposed, this reduced silver in the solution can then deposit on them and so the image will be built up; the rate of deposition will, however, be considerably retarded by the gelatin, that is, the apparent rate of reduction of the silver bromide, as measured by the deposition of silver, will be much less than that of medium-free bromide. In the case of the unexposed grain there are no silver nuclei, and, therefore, deposition of silver from the solution cannot take place. This is substantially the explanation given by Lüppo-Cramer and Reinders, but there are difficulties in the way of accepting it for the unexposed grain. If the gelatin

does not retard the solution of the grain, reaction between the dissolved silver bromide and the developer will go on as usual, and if no deposition of silver takes place there must ultimately be a supersaturation so great with respect to it, that it is difficult to postulate its existence. One way out of the difficulty is to suppose that the supersaturated silver tends to reverse the reduction reaction, and so its increase in concentration is limited; a mechanism of this kind would be favoured by the protecting action of the gelatin, which prevents the agglomeration of the amicrons to the larger particles which would separate out as nuclei. This is analogous to the theory of Mees and Sheppard that the function of the gelatin is to act as a filter against nuclei. Even in this case, however, nuclei will form after a time, so that deposition of silver will take place and there will be general fogging, as is known to be the case with prolonged action of the developer.

It is well known that the silver produced by development of photographic plates and papers may vary in tone from a deep black to a greyish-white, and also that it may have colours ranging over the visible spectrum. Dealing first with the black tones, attention may be called to some experiments of Lüppo-Cramer, who has published a considerable amount of work on the subject. In his early experiments he came to the conclusion that when the silver results from a very rapid reduction of its compound it separates in a very finely divided condition (the A-form) and is consequently black, whereas when the rate of reduction is slow the particles are much coarser, owing to Ostwald ripening having time to come into operation, and hence the colour is lighter, tending to greyish-white (the B-form). This difference in the size of the particles is evidenced by the fact that the A-form is quickly bleached by a solution of mercuric chloride, whilst the B-form turns only a dark colour with the same reagent.

Later investigations did not confirm the above-mentioned conclusion that the varying colour was due to a difference in the size of the particles, as is shown by the following: To 100 cc. of a 2% solution of purified gelatin were added 4 cc. of a 10% solution of silver nitrate, 10 cc. of a 1% solution of potassium citrate, and then 4 cc. of a 10% alcoholic solution of hydroquinone. The silver citrate first produced was reduced to silver, which was deep black in reflected light. A similar experiment in the absence of citrate gave a silver which was light grey in reflected light. Microscopic examination of these two forms of silver showed that there were no characteristic differences, either in shape or in size. Nevertheless there was a difference in the internal structure of the separate particles, since the black silver was much more quickly bleached by mercuric chloride than was the grey silver. The difference in colour of the two forms of silver is, therefore, really due to a difference in the internal dispersity of the particles. In the production of the black silver the silver citrate first produced is colloidal, and probably, as long as it is present, has a protecting effect, in addition to that of the gelatin, on the silver as it is formed.

These different forms of silver play a part in ordinary photographic practice. For example, the addition of soluble bromides to a developer in order to reduce the effect of over-exposure has a considerable influence on the character of the reduced silver. If large quantities of bromide are present, development is much slower and instead of the ordinary black silver the light-grey form is produced. It is possible that the effect of the bromide is not simply due to the retardation it has on development, but that it diminishes to some extent the protecting action of the gelatin, since it is known that bromides lower the melting and setting points, and viscosity of gelatin.

Even in an ordinary negative the silver in the various parts varies in dispersity; when treated with mercuric chloride solution the shadows, which consist of the most highly disperse silver, begin to bleach first, then the middle tones, and finally the high lights. This order of reaction is not always the same with different reagents; for example, when the image is reduced with persulphate the high lights are first attacked. This apparent anomaly is due to the fact that during the fixing the image may adsorb impurities from the bath or be attacked and changed to some extent by the fixing agent; whatever action takes place will be the more marked the more highly disperse the silver. It follows that the silver in the high lights remains the most pure, and as regards the action of persulphate, it is then the more readily attacked. It should be mentioned that other explanations of this action of persulphate have been given.

Beside the black tones of the ordinary image, it is well known that coloured images may be obtained directly by appropriate methods of development. These colours are analogous to those obtained with silver sols in which the particles vary in size. A large amount of work has been published on coloured silver sols containing gelatin as protective colloid, especially by Lüppo-Cramer, but the most exact observations have been made comparatively recently by Schaum and his co-workers. They prepared what is known as a nucleus sol, containing very highly dispersed silver, according to the following modification by Lüppo-Cramer of Carey Lea's original method. 10 cc. of a 10% solution of yellow dextrin, 10 cc. of 10% sodium hydroxide, 7.5 cc. of 10% silver nitrate, and 22.5 cc. of water are mixed, the mixture being diluted to 1500 cc. after half an hour. This nucleus sol is practically optically clear, transmitting brownish-red light which becomes pure yellow in very thin layers or on high dilution. To a definite quantity of the nucleus sol were added successively definite quantities of a 1% solution of gelatin, followed by definite volumes of solutions B and A, solution A being added last. Solution B consisted of 2 grams of crystallised sodium sulphite and 2 grams of *p*-phenylenediamine dissolved in 100 cc. of water, and solution A of 18 grams of crystallised sodium sulphite and 0.75 gram of silver nitrate dissolved in 100 cc. of water. The various sols were then obtained as in the following table, which also gives the colours in transmitted (T) light before and after dilution.* In this method of preparation each sol contains particles from the proceding sol as nuclei on which deposition of silver can take place. As we proceed from sol 1 to sol 7, therefore, the particles should increase in size, and in accordance with this it is found that the strength of the Tyndall cone increases in the direction 1 to 7.

The relation between colour and the size of the particles in suspensoid sols of metals is a very complicated one, since in the passage of light through the sol some of it is absorbed by the particles and some of it scattered. In his work on gold sols Steubing has shown that for particles 20 $\mu\mu$ in diameter the scattering is very small, and for particles of 2-4 $\mu\mu$ it is immeasurable. Such sols, therefore, behave towards light in the same way as true solutions of dyes, that is, the colour of a very highly dispersed sol is not that of a turbid medium, analagous to that of the blue colour of the sky, but is due to a specific absorption by the particles of the dispersoid, which absorption can be calculated from the optical constants of the particles and will depend on their size. In such sols the relation between the colour of the transmitted light (subjective colour) and that absorbed is given by Table A, due to Wo. Ostwald.

In the silver sols prepared by Schaum the particles are larger than 20 $\mu\mu$ in diameter, their sizes, as measured in the ultramicroscope after stabilising the sols in gelatin, being found to vary from 70 $\mu\mu$ in the orange coloured sols to 180 $\mu\mu$ in the blue-green sols. The relation between the subjective colour of the sol and the colour of the particles as seen in the ultramicroscope, which corresponds with the absorbed colour in the above table, will, therefore, be somewhat modified, but, as shown in table B, there is an approximate agreement between theory and experiment.

Nucleus sol.	1% Geln. cc.	Soln. B. cc.	Soln. A. cc.	T.	T (after dilution)
I. 0.2cc.	9.2	0.2	0.4	Orange-red	Yellow
II. 5cc. of sol I.	4.5	0.1	0.2	Deep red	Yellow-orange
III. 5cc. of sol II.	4.5	0.1	0.2	Deep red	Orange
IV. 5cc. of sol III.	4.5	0.1	0.2	Dark red	Orange red
V. 5cc. of sol IV.	4.5	0.1	0.2	Purple	Red violet
VI. 5cc. of sol V.	4.5	0.1	0.2	Blue violet	Blue violet
VII. 5cc. of sol VI.	4.5	0.1	0.2	Blue green	Blue green

Having dealt with the way in which silver sols of various colours can be obtained when gelatin is present as a protecting agent, the colour effects which are produced by development may now be considered.

* For demonstration purposes the coloured sols are best prepared by Lüppo-Cramer's method. To 500 cc. of a 2% solution of purified gelatin are added 20 cc. of a 10% silver nitrate solution. To separate quantities of 100 cc. of this solution, warmed to 30°, are then added respectively (*a*) 0.5 cc. (*b*) 2 cc. (*c*) 5 cc. (*d*) 10 cc. of a fresh nucleus sol prepared as in the text, followed by 0.5 cc. of a 1% solution of sodium phosphate and then 4 cc. of a 10% alcoholic solution of quinol. After 20 minutes the transmission colours are (*a*) blue, (*b*) violet, (*c*) red, (*d*) yellowish red. If the sols are diluted with an equal volume of 10% gelatin, coated on glass and dried, the colours become finer and are displaced towards the blue end of the spectrum. In order to obtain a dry, red film, it may be necessary to use 20-30 cc, of the nucleus sol.

Table A.

Wave length in $\mu\mu$	700	650	600	550	530	500	480	450	430	400
Absorbed colour	Purple	Red	Orange	Yellow	Green yellow	Green	Green blue	Blue	Indigo	Violet
Subjective colour	Green	Green blue	Blue	Indigo	Violet	Purple	Red	Orange	Yellow	Green yellow
Wave length in $\mu\mu$	500	480	450	430	400	700	650	600	550	530

Table B.

Sol.	Subjective colour of diluted solution.	Colour of particles.	Absorbed colour according to table.
I.	Yellow	Weak bluish-violet	Indigo*
II.	Yellow orange	Weak blue	Blue
III.	Orange	Stronger blue	Blue
IV.	Orange red	Chiefly blue; some blue-green and orange	Blue-blue green
V.	Reddish-violet	Many blue-green, orange and red†	Blue-green
VI.	Bluish-violet	Chiefly orange and yellow	Yellow-green yellow
VII.	Bluish-green	Yellow and White	Red

* This, as a spectrum colour, may be classed as bluish violet, since many observers cannot distinguish an indigo in the spectrum.

† Evidence was obtained that the red of these particles was a contrast colour, and not real.

Whenever the developer contains a solvent for silver halide the rate of development is very much diminished and there is a tendency for the formation of coloured silver. This latter may be deposited in the form of what is known as dichroic fog, or else a coloured image is produced. This image in some cases, at all events, probably consists of black particles of microscopic size in conjunction with the coloured silver sol, since brown and sepia tones are not formed in the true silver sols. It has long been known that if lantern slides, which contain a fine grained emulsion, were developed with a developer containing ammonium carbonate as a silver halide solvent and ammonium bromide as a restrainer warm tones in sepias and browns were obtained. It was shown by Mees and Wratten in 1909, who used the ultramicroscope in their observations, that at the commencement of development a yellow tone is obtained, which is succeeded by reds, browns and sepias as the grains of deposited silver grow in size. They improved this method of obtaining tones by development by using thiocarbamide in addition to ammonium carbonate as a solvent for the silver halide; greens, blues and violets can thereby be obtained. This method has been particularly studied by Mr. Dudley Johnston, the President of the Royal Photographic Society, and by investigating the effects of temperature, exposure, and variations in the developer he has brought the process to perfection. The slides now shown have been made by Mr. Dudley Johnston and kindly lent to me for demonstration purposes.

Recently, Messrs. Thorne Baker and Davidson of the Imperial Dry Plate Co. have also studied this method of obtaining direct colours on lantern plates, and some of the results obtained are shown in the next few slides, which have been kindly supplied by Mr. Thorne Baker. With a warm-tone lantern plate, as the exposure is increased and the time of development in caustic soda-quinol developer diminished, colours ranging from black through sepia, brown and red to deep orange are obtained. Using a metol-quinol developer and an ammonium carbonate bromide restrainer, colours are similarly obtained, not only with warm-tone lantern plates but also with gaslight lantern plates, the colours with the latter being especially brilliant.

Similar colours can be produced in the physical development of primarily fixed plates. For example, silver chloride-gelatin plates are exposed to give a weak visible image, fixed, and thoroughly washed. If developed with acid-metol silver, the precipitated silver is at first pure yellow and then changes through orange into red, reddish-violet, and finally blue.

As long ago as 1894 the Liesegangs gave a method of obtaining variously coloured prints on a silver chloride-gelatin paper.

They found that the longer the exposure and the diluter the hydroquinone developer, the yellower is the colour of the silver produced, as shown by the following table.

Tone of dry print.	Rel. Exposure.	Dilution of Developer.
Green black	1	1 : 5
Olive Green	2	1 : 5
Sepia	3	1 : 10
Brown	4	1 : 10
Red brown	6	1 : 20
Yellow brown	8	1 : 20
Red	5	1 : 30
Reddish	10	1 : 30
Yellow	20	1 : 40

These colours are really transmission colours, depending on the size of the silver particles, since the light is reflected from the white surface of the paper base.

The different colours obtained with the various printing-out papers before toning are similarly dependent on the size of the particles, this size being again dependent on that of the original grain of silver halide.

So far gelatin has been considered only as the medium in which the silver halide is dispersed, and the question has not been raised as to whether it is contained in the grains of the silver halide themselves. During the ripening of the emulsion the grain changes from an apparently amorphous condition to one which is definitely crystalline, that is, from a less stable to a more stable state, and one would, therefore, expect that it would be less sensitive to light. Actually it becomes more sensitive, and, at first sight, it would seem that the way out of the impasse is to assume that the grain really consists of some kind of combination of gelatin with silver halide, the effect of ripening being to alter this combination in such a way that the grain becomes more sensitive. This is not necessarily a valid assumption, however, since, as will be seen later, the sensitive spots on the ripened grains appear to be congregated on the surface, where conditions, owing to adsorption effects, may be quite different from those holding in the mass of the grain itself.

Eder has attempted to show that the grains contain gelatin by centrifuging them out from an emulsion after rapid washing with warm water; the separate grains were still found to contain about 2% of gelatin. This is no proof, however, that gelatin is contained in the grains; the gelatin remaining may be that which is adherent to the grains, since it is extremely difficult to remove adsorbed substances from a surface by mere washing.

If gelatin is present in the grain it is quite possible that as the emulsion dries the grains themselves will diminish in volume. Bellach after several days' drying, found a contraction in area of the grains varying from 0.57×10^{-5} to 0.67×10^{-5} sq. mm., but Hodgson and also Sheppard and Trivelli were not able to detect any difference in the dimensions of the grains in one and the same wet and dry emulsion. These observations are not necessarily contradictory, however, since the swelling or non-swelling may depend on the way in which the gelatin, if present, is distributed in the grain and on the resistance of the layers of silver halide to displacement.

The question has been attacked in another way by Reinders. If crystals of silver chloride, obtained by evaporation of an ammoniacal solution of the salt, are exposed to sunlight, they gradually become blue in colour, owing to the formation of silver, produced by photochemical decomposition, and its colloidal solution in the remaining silver chloride. The silver thus produced may amount to as much as 1% and is left behind as a residue when the chloride is dissolved in concentrated ammonia solution or in a solution of sodium thiosulphate. Silver chloride coloured in this way is known as photochloride; it may be produced artificially by allowing the crystals to form, in the dark, from an ammoniacal solution of silver chloride containing also colloidal silver, and the colours obtained may vary from yellow, through red, to reddish-violet and blue-violet, according to the colour of the silver sol used. The crystals so obtained are homogeneous in structure and colour; on exposure to diffuse daylight they gradually become indigo-blue, the colours of the lighter crystals going through yellow, red, red-violet, blue-violet and finally indigo-blue. The velocity with which the colour

change takes place is always much faster than the production of colour from the colourless, pure silver chloride crystals. Moreover, with the latter the colour is confined to the surface, the interior being unchanged, whereas with the former the colour is uniform throughout the crystal. Now, when the crystals of silver chloride were produced from a solution containing gelatin, they also were found to be more photosensitive than the pure salt, and the blue colour produced on exposure was uniform throughout the crystal and not confined to the surface. It, therefore, follows that the gelatin was evenly distributed throughout the crystal, just as was the colloidal silver in the previous experiments. From a 2% gelatin solution the crystals contained 0.1% of gelatin but the influence of gelatin would be shown in crystals formed from a solution containing only 0.001% of gelatin, that is, one milligram of gelatin in 10 litres. It was further found that the addition of gelatin to the ammoniacal solution of silver chloride containing also colloidal silver, prevented the crystallising salt from taking up silver, that is, the adsorption of one colloid was prevented by another.

It is true that the above experiments of Reinders do not prove that gelatin is present in the silver halide grain of a photographic emulsion, but, reasoning by analogy, it seems safe to conclude that gelatin must be present, especially since the concentration of gelatin present during the emulsification is so much greater than in Reinders' experiments. Bancroft, from his study of the literature, comes to the conclusion that the grain contains both gelatin and water, and that there is a maximum sensitivity for a definite but small amount of both these constituents, the sensitivity decreasing when the proportions of these substances are greater or less than the optimum values. In support of his ideas he states the following: A silver bromide which contains no gelatin or extremely little is not so sensitive as a silver bromide containing gelatin. The photographic emulsion is also not especially sensitive if it is rich in gelatin, much speedier emulsions being obtained if the silver bromide is precipitated from a solution containing only a moderate amount of gelatin. Drying a photographic plate increases its sensitiveness up to a certain point and there must, therefore, be a limiting content of water for which the sensitivity is a maximum, everything else remaining the same.

Since gelatin is known to react with the halogens, especially with chlorine and bromine, Reinders's experiments would seem to indicate that it plays the part of a sensitiser in the photochemical decomposition of the silver halide. There has been much discussion about this, and Lüppo-Cramer claims to have proved that gelatin has no sensitising action, since he found that a collodion emulsion plate coated with gelatin did not give a print-out effect quicker than one not so coated. This experiment proves nothing, however, since any sensitising effect is not necessarily due to the gelatin surrounding the grain, but may be caused by the gelatin actually forming part of, or adsorbed firmly by, the grain. Schumann, on the other hand offers definite evidence that gelatin may act as a sensitiser. He covered one half of a glass plate with gelatin, leaving the other half bare; the plate was then put in the bottom of a vessel in which silver bromide was produced by precipitation and gradually settled down. After deposition of the precipitate the plate was lifted out, carefully washed, dried, exposed to light, and then tested with a developer. There was found to be practically no change in the silver bromide which had been in contact with the bare glass, but there was an abundant formation of reduced silver in the silver bromide which had been in contact with the gelatin.

LA VIE INDUSTRIELLE EN FRANCE.

Le Centenaire de L'Industrie du Gaz en France & Le Cinquantenaire de la Société Technique de L'Industrie du Gaz

La Société technique de l'Industrie du Gaz a fêté tout récemment le cinquantenaire de sa fondation, qui coincide, sinon précisément avec le centenaire de l'invention du gaz d'éclairage, du moins avec celui de l'essor de cette industrie naissante, tant à Londres qu'à Paris

On peut discuter sur les mérites respectifs, comme inventeurs, de l'ingénieur français Philippe Lebon, de l'anglais William Murdoch, et du physicien hollandais Minckelers; bornons-nous à dire que la mémoire de Philippe Lebon a été honorée, en France, par l'érection, déjà ancienne, d'une statue et, cette année, par la pose d'une plaque sur l'emplacement de la première usine à gaz française, construite en 1818 dans l'hôpital Saint-Louis, à Paris, pour les besoins de cet établissement.

D'autre part, la Société technique du Gaz a donné plus d'éclat à son Congrès annuel, en organisant une Exposition du Gaz qui s'est tenue au Jardin d'Acclimatation du Bois de Boulogne.

On y voyait les principaux types d'appareils à gaz modernes, soit industriels (fours), soit domestiques (fourneaux, radiateurs, chauffe-bains, becs à incandescence, etc)

Une remarquable section rétrospective montrait la série des becs usités depuis un siècle pour l'éclairage public, divers appareils historiques tels que celui de Dumas et Regnault pour la vérification du pouvoir éclairant du gaz par rapport à la lampe Carcel étalon, le brevet de 1799 et la brochure de propagande de Philippe Lebon, etc

Le Congrès a discuté de nombreuses communications, ayant trait notamment au débenzolage du gaz de ville, à son épuration, à la distribution du gaz dans Paris, au gaz des cokeries, et à beaucoup d'autres questions diverses

Enfin, une "Semaine gazière" réservée au personnel des Sociétés gazières, comportait des conférences d'ordre technique et pratique, et des visites d'usines ; elle a été également très suivie, et cet ensemble de manifestations a montré que l'industrie gazière, malgré la concurrence de l'électricité, a encore devant elle un champ immense d'applications

Le Nouvel Établissement Balnéaire de la Ville de Paris, à la Butte aux Cailles

La Ville de Paris, qui ne possédait pas jusqu'ici de piscine vraiment moderne, en possède aujourd'hui deux qui peuvent rivaliser avec les mieux aménagées des grandes villes d'autres pays : l'une, à ciel ouvert, et de grandes dimensions, est destinée spécialement aux épreuves sportives (piscine des Tourelles) ; l'autre, établissement balnéaire complet avec piscine couverte et bains-douches en cabines, est destinée principalement aux besoins de la population ; toutefois, des tribunes sont installées au-dessus de la piscine pour permettre aussi des épreuves publiques de natation.

Nous ne parlerons ici que de ce dernier établissement, situé dans le quartier de la Butte aux Cailles, près de la place d'Italie. Sa charpente en arcs de béton armé donne au grand hall de la piscine un aspect très satisfaisant ; la piscine, de 33 x 12 m. (108 x 39½ feet), avec profondeur variable de 0m75 (2½ft.) à 3m (10ft.), est également une vaste cuve en béton armé portée par des piliers de même nature, de sorte qu'on peut accéder au-dessous du fond et contrôler son étanchéité.

Une autre particularité remarquable de l'établissement, c'est qu'il est alimenté directement par l'eau à 28° centigrades du puits artésien de la Butte aux Cailles, situé tout près de là, et qui débite 72 mètres cubes (15,840 gallons) par heure, de sorte qu'on peut, sans réchauffage, entretenir la piscine en eau presque courante, par conséquent toujours propre. Du reste, on dispose aussi de l'eau de source du réseau municipal, que des chaudières permettent de réchauffer selon les besoins. Les mêmes chaudières servent pour les bains-douches annexés à la piscine, et pour le chauffage de l'air des halls et salles de déshabillage.

Ce bel édifice, agencé de la façon la plus moderne, a coûté environ 4 millions de francs

Piano Électrique, Système Martin & Maitre.

On reproche souvent au piano le caractère fugitif et presque saccadé des sons émis par les cordes vibrantes sous le choc du marteau, bien inférieurs aux sonorités persistantes du violon ou de l'orgue, que l'exécutant prolonge à son gré, ou relie entre eux sans aucune interruption

Sans doute, les virtuoses du piano, par la perfection de leur jeu, atténuent cette infériorité inhérente à la nature même de l'instrument, mais il n'en serait pas moins très désirable, pour la grande majorité des pianistes, de disposer d'un instrument plus souple, plus nuancé, sans renoncer pour cela aux avantages d'articulation nette que permet la technique de la corde frappée par un marteau

Après de longs essais, deux inventeurs de Rouen, M.M. Martin & Maitre, ont trouvé une solution ingénieuse à ce problème difficile. Leur piano électrique, dit "Pianor," comporte, juste devant chaque corde en acier, un petit électro qui, par l'envoi ou la rupture du courant, la fait vibrer comme sous le choc du marteau, avec un son plus pur. Si le pianiste continue à appuyer sur la touche, la corde elle-même, par l'intermédiaire d'un petit mécanisme commandé par un diapason, entretient indéfiniment son mouvement vibratoire, et la note se prolonge ainsi, aussi longtemps qu'il convient à l'exécutant

Du reste, les marteaux du piano ordinaire ne sont pas supprimés dans le nouvel instrument, de sorte qu'on peut à volonté : jouer à la façon ordinaire, avec les marteaux seulement ; obtenir un effet d'orgue, en jouant avec le système électrique, sans que les marteaux frappent les cordes ; combiner les deux effets, en plaquant les accords avec les marteaux, et en filant le chant en sons continus analogues à la flûte ou au hautbois.

Ce remarquable instrument, susceptible de donner un grand charme à l'exécution des morceaux d'orchestre dont la réduction pour piano est généralement sèche et trahit les richesses de l'œuvre originale, peut aussi, par un effet inverse, rendre de grands services aux compositeurs, qui, au piano, ne peuvent se rendre un compte exact des effets d' orchestration qu'ils ont médités.

NOTES ON BOOKS.

Time Measurement : an Introduction to the Means and Ways of reckoning Physical and Civil Time. By L. Bolton. London : G. Bell and Sons, Ltd. 6s. net.

In the compass of 166 pages, Mr. Bolton gives us an accurate and concise account of timepieces in which matter or stuff moves, from the water clock of the Greeks and Romans (Clepshydra) and its near kin the sand-clock, the lamp clock and

the oil clock, to the modern chronometer and the instruments in the chronograph room at the National Physical Laboratory: essential or characteristic mechanical features being well illustrated and described. In the preface our author pays tribute to the merits of such clocks as have come down to us from Plantagenet times and pleads for the judging of such clocks rather by their works (movements) than by the dials and externals.

As regards the word *cloche* (French) and *cloch* (Welsh) parallels with our *clock*, we are reminded (p. 52) of the tradition that some of the early clocks had no means of indicating but the sound of the bell. This tradition appears to be somewhat confirmed by Vitruvius in the tenth book of his *De Architectura*, where he describes as old (*a majoribus traditam*) a device by which each mile of the distance travelled by a land-car (rheda), or by a ship, can be indicated by sound to the ear when a ball falls into a brazen vase (or bell), and the total being visible at any time by counting the balls in the bell. The balls are placed, each in one of a number of perforations which are equally spaced in the rim of a horizontal wheel, and when a ball comes over a gutter in the underplate it rolls down and falls into the bell. With suitably timed driving this device may obviously indicate hours, and in either case the set to zero would by returning the balls to the holes in the rim of the horizontal wheel. Thus we have the germ of a "clock" movement in the sense of bell indication which was suggested or perhaps constructed and used about 2,000 years ago. In relation to the car, Vitruvius mentions a gearing down of 400 from a road wheel of four feet diameter as appropriate for indicating the Roman mile of 1,000 complete or 5ft. paces. Versions of Vitruvius differ somewhat, but all the above details are, we believe, common to most or all. Our immediate source is the stereotyped small octavo text of Tauchnitz dated 1838, pp. 229-231. This matter is in the tenth book, chapter IX. (called Chapter XIV. in some versions).

Time-pieces in which no material, but only a shadow moves, are considered with corresponding thoroughness, and we may refer to the plate opposite p. 48, showing a group of sundials; also the improvised clinometer represented on p. 49, as giving a ready means of extemporising sundials if used in accordance with the lessons taught by the armillary sphere, Fig. 2, p. 29. The meridian dial, Fig. 12, p. 50, is interesting as serving to indicate noon only, as is the case with the dipleidoscope of Dent, but this latter, when properly set, gives an indication which is exact to the fraction of a second. Either instrument may be provided with an addition by which the actual reading gives mean noon as distinguished from apparent noon. In the case of the meridian dial the addition is a graph of the equation of time; this graph being shown by Fig. 12. A good illustrated account of Dent's dipleidoscope is to be found in "Cassell's Illustrated Exhibitor, 1851 and 1852," pp. 530-531.

General data as to the various aspects of astronomical time, the various kinds of "day," also the distinction between the real sun and the mean sun are given much in the sense of the statements in the Nautical Almanac, but in language better suited to the general reader, and with diagrammatic aid where desirable.

VANADIUM ORES. By Members of the Scientific and Technical Staff of the Imperial Institute. With a map. London: John Murray. 5s. net.

The only fault which we can find with this recent addition to the Imperial Institute's series on Metallurgic Geography with special reference to the British Empire, is that the short title does not do justice to the thorough and masterly way in which the more essential elements of collateral information are introduced.

About a page on the discovery and properties of vanadium, emphasises the sources of liability to mistake in recognition and in respect to reduction: also cites five representative vanadium compounds and indicates such trends of affinity as may lead to subversive results in actual practice. This exceptionally thorough example of concise but suggestive technical writing will not only serve to introduce vanadium to the beginner, but will also remind the most experienced chemical worker of the danger points in relation to observation, research and practice.

Another page gives a preliminary note as to vanadium ores with clear indications as to composition, and where necessary, companionship and locality; but this account is not burdened by formulæ.

Then, on page 3 under the heading "Occurrences of Vanadium," the close systematic body of the book commences with quantitative study of vanadium in the earth's crust and the conditions influencing localisation: also how localisation and companionship may have determined the nature of the ore. The metallurgy of vanadium (pp 7-10) is introduced by a more elaborate study of the chief ores with chemical formulæ, followed by a concise but sufficient account of the leading or typical methods of reduction.

Under "Uses of Vanadium," there is brief mention of use as a catalyst, dyeing and mordanting, marking ink, decorating pottery, photography and medicine; the chief use, however, is in the formation of alloys, as with steel, copper or aluminium, the usual effect being to toughen the metal and give it an increased power of resisting repeated shocks, one of vanadium in four hundred of steel giving much about the same result as a greater quantity.

Detailed study of the world's production of Vanadium ores, from the geographical, industrial and financial aspects concludes with a world map (pp. 13-65), after which a bibliography of seven pages completes this book, which may not only be regarded as a concise introduction to the subject of vanadium but also as a useful lesson to any one intending to write a practical text-book on industrial chemistry.

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PROCEEDINGS OF THE SOCIETY.

COBB LECTURES.

CERTAIN FUNDAMENTAL PROBLEMS IN PHOTOGRAPHY.

By T. Slater Price, O.B.E., D.Sc., F.I.C., F.R.S.

(Director of Research to the British Photographic Research Association).

Lecture III.—*Delivered April 7th*, 1924.

The preceding discussion of the effect of gelatin on the photosensitivity of the silver halide grain leads naturally to the questions of the visible and latent images. Dealing first with the visible image, there is no doubt that when the silver halides are exposed to the light halogen is set free; this has been proved experimentally, and is confirmed by the fact that the darkening, which accompanies the fission of the halogen, is accelerated in the presence of compounds which absorb halogen and, therefore, act as sensitisers. Thus, printing-out papers contain, in addition to the silver halide, silver nitrate or the silver salt of an organic acid, especially citric acid, which acts as a sensitiser. Doubt comes in however, as soon as the nature of the dark product formed on exposure, the photo-halide, is considered. According to some investigators, of whom Carey-Lea was notably the pioneer, the photohalide is a sub-halide, Ag_2X, where X = Cl, Br or I, or a "lake-like" combination of the sub-halide with the normal halide in varying proportions, and in favour of this it is stated that a sub-fluoride of silver, Ag_2F, has been isolated by Guntz. All attempts to prepare corresponding sub-salts containing the other halogens have not met with success, however, and doubt has even been expressed as to the unitary character of the so-called sub-fluoride. At one time Luther put forward what was considered to be definite evidence based on potentiometric measurements, but succeeding investigators have not been able to confirm his results. The alternative explanation of the nature of the photo-halides is that they consist of colloidal solutions of silver in excess of silver halide. In favour of this are the experiments of Reinders, already quoted, and also those of other investigators. Thus it was found by Lüppo-Cramer that if a silver sol is added to a sol of silver halide and the mixed sols then precipitated with sulphuric acid, a coloured product identical in its properties with the photohalide is obtained. Lüppo-Cramer has adduced considerable further evidence, but it should be mentioned that, as a result of his experiments on the preparation of various "soluble," allotropic modifications of silver, Carey Lea first suggested that silver in the photo-halides was present as allotropic silver.

The usual explanation given of the sensitising action of silver nitrate with respect to the visible image is that it removes the bromine set free by the action of light, in accordance with the equation:—

$$Br_2 + AgNO_3 + H_2O = AgBr + HOBr + HNO_3.$$

The matter is, however, by no means as simple as is represented by the above equation, since adsorption effects undoubtedly play a part. It has been proved experimentally that when silver bromide is precipitated from a solution containing excess of silver nitrate, some of the excess silver ions are adsorbed on the surface of the precipitate and cannot be removed by washing. Similarly, if the precipitation takes place in the presence of excess of potassium bromide, bromide ions are adsorbed. If the concentrations used are such that the silver bromide is obtained as a sol, the particles are positively charged when the silver nitrate is in excess, and negatively when the bromide is in excess, as would be expected from the electrical charge on the adsorbed ions. The two kinds of silver bromide may be spoken of as "silver-body" (Ag-body) and "bromide-body" (Br-body) respectively.

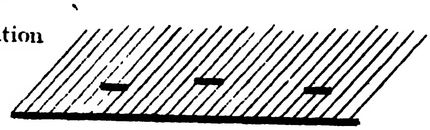
The question naturally occurs as to whether these adsorbed ions play any part in the photosensitivity of the silver bromide. To answer this, it is necessary to refer to modern work on crystal structure. It has been shown that even apparently amorphous silver bromide has a lattice structure such that each silver atom is surrounded by six bromine atoms, and each bromine atom in its turn by six silver atoms. Owing to electron interchanges the silver atoms are positively charged and, therefore, may be termed silver ions; similarly the bromide is present as bromide ions. A section through the crystal may, therefore, be represented as follows, the +'s representing the silver ions and —'s the bromide ions.

```
+   —   +   —   +   —

        ↑
—   +   —   +   —   +
                         1
+   —   +   —   +   —

—   +   —   +   —   +
```

Assuming that the action of light is electrical in its nature, the process which takes place on exposure may be represented as the transfer of an electron from a Br-ion to a Ag-ion as shown by the arrow, with the formation of neutral atoms of bromine and silver.

The Ag-body must be represented as having silver ions attached to its surface as in diagram 2, the points of attachment being the oppositely charged Br-ions.

Solution



```
        +       +       +

    +   —   +   —   +   —
Grain                            2
    —   +   —   +   —   +

    +   —   +   —   +   —
```

The negative ions represented as in the solution are the NO_3-ions from the silver nitrate. Various considerations based on the extent of the hydration of ions, and which need not be entered into here, show that the electrostatic action of the NO_3-ions may be neglected, so that 2 simplifies to 3.

```
        +       +       +
                ↑
    +   —   +   —   +   —
                               3
    —   +   —   +   —   +

    +   —   +   —   +   —
```

Compared with pure silver bromide, 1, the surface of 3 is so altered that the photochemical processes will be affected. Consider in 1 and 3 the transfer of an electron from the Br-ion to the Ag-ion, as represented by the arrow. Assuming all other things to be equal, in 1 the negative Br-ions on either side of the Ag-ion will have a repelling effect on the transfer of the electron, both in its initial and final positions. The repelling effect will be greatest in the final position, since the Br-ions on either side of the Ag are then nearer to it than they are to the Br-ions in the layer underneath. Compared with 3, therefore, it will be more difficult for the transfer of an electron to take place, that is, the Ag-body, 3, should be more sensitive to light than the pure substance 1, in the sense that its spectral sensitivity should be extended towards the red.

The above considerations are due to Fajans and his co-workers, especially Frankenburger, and have been tested experimentally. It was first shown that in the presence of silver nitrate a sufficient density of Ag-ions covers the surface of the silver bromide for the surface itself to be considered changed. By exposure to light of various wave lengths, obtained by the use of appropriate filters, it was found that pure silver bromide, which had been dried in a cathode-light vacuum at 300°-350°, visibly darkened in an inert atmosphere between 410 and 435$\mu\mu$, but was unaffected by longer wave lengths. In the case of the Ag-body, however, darkening took place over all wave lengths between 400 and 620$\mu\mu$. The Ag-body was made by precipitating 25 cc. of N/5 silver nitrate with 20 cc. of N/5 potassium bromide, the excess of silver nitrate acting as an acceptor for the bromine liberated by the action of light. The Br-body, which can be represented similarly to 3, using, however, —'s in place of +'s for the adsorbed ions, was made similarly to the Ag-body, using an excess of potassium bromide. It behaved similarly to, and had the same threshold value as pure silver bromide, namely 410-435 $\mu\mu$. In the case of both the Ag- and the Br-bodies it was

proved analytically that bromine is set free by the action of light.

The most interesting results were obtained when the well-washed Br-body was exposed under alkaline solutions (sodium hydroxide, sodium carbonate, or ammonium hydroxide). It was then found to be sensitive over the same range as the Ag-body, that is, between the wave lengths 400 and 620 μμ. The most important fact, however, was that when photochemically decomposed there was no liberation of bromine. It follows, therefore, that the increased sensitivity must be due to the decomposition by light of a substance analogous to silver hydroxide, and not of silver bromide, that is, that adsorbed Br-ions in the Br-body had been replaced by OH-ions, forming an hydroxide-body (OH-body). Such adsorption replacement is a well-known phenomenon. In agreement with this it was shown that pure silver oxide is sensitive over the same region of the spectrum as is the Br-body under alkaline media. The transfer of an electron from from OH-ion to Ag-ion thus seems to take place more readily than the corresponding transfer from Br-ion.

Another important result concerned the sensitising action of silver nuclei. The Br-body, and also pure silver bromide, which were sensitive to wave lengths of 435 μμ and less, but not to longer wave lengths, became sensitive under a filter transmitting 560-720 μμ after previous exposure under a filter transmitting 410-510 μμ. Silver nuclei are formed in the first exposure and these have a sensitising or accelerating action in the second exposure. This sensitising action can be accounted for by an extension of the theory given previously. The results agree with the known fact that colloidal silver acts as a panchromatic sensitiser of the photographic plate. Eder has shown that after a short exposure the silver halides are more sensitive to long wave lengths than before, and Carey Lea and Lüppo-Cramer have demonstrated that the synthetic photohalides also show a similar spectral sensitivity.

The OH-body seems to be most important, since minimal quantities of substances which react alkaline can produce the effect. Washed Br-body, when boiled for a long time under water in the light of a photographic dark room, becomes discoloured, probably because alkali is dissolved from the glass of the containing vessel; OH-body is thus formed, and this is sensitive to the light of the dark room. With tap water in place of twice-distilled water, darkening takes place in a comparatively short time, because of the basicity of the carbonate-containing water. Now since OH-ions so readily replace adsorbed Br-ions, it is probable that the latter will also readily be replaced by the anions of organic acids and dyes which give soluble silver salts, and it is possible that this adsorption replacement accounts for a number of sensitising effects, the transfer of an electron to the Ag-ion being thereby facilitated. In support of this idea it may be mentioned that Weigert has shown that in silver halide emulsions containing organic silver salts in addition, the photochemical process consists in the decomposition of these salts, which are thus more sensitive than the silver halides. This recognition of the influence of adsorption and adsorption-replacement reactions will probably play a great part in the advances made in photography in the future. Mees, Sheppard, Bancroft and others have considered the question of adsorption in the past, but not in the definite manner due to Fajans.

As compared with the visible image the difficulties are very much enhanced when the latent image is considered, since further complications arise owing to the fact that the presence of a latent image is only made known by the process of development. The amount of concrete and definite evidence is not large, and the opinions held are so varied, that it will be sufficient to deal with the subject somewhat briefly. Broadly speaking, there has been a division of opinion as to whether the formation of the latent image involves a physical change only in the silver halide, or a chemical change. Of physical theories there have been several. Some of them have been exactly opposite in character, Namias, for example, assuming that the silver halide grain is polymerised by the action of light, whereas Hurter and Driffield assumed depolymerisation of a complex molecule. Other physical theories were those which assumed mechanical disintegration of the grain (Bredig), the formation of a labile modification (Chapman Jones), or that the grain was thrown into a state of molecular strain (Bose). As pointed out by Bancroft, however, all these physical theories seem to be put out of court by the fact that the action of light can be duplicated by immersing the plate

in a solution of a weak reducing agent; such as stannous chloride or sodium arsenite, after such immersion the plate can be developed by means of an ordinary developer.

There have been two chief chemical theories. The one assumes the formation of a sub-halide of silver, which is then readily acted on by the developer, but, as already pointed out, no definite evidence has been adduced for the existence of such sub-halides, except silver sub-fluoride. The other theory supposes that the latent image consists of silver, set free by photochemical action, which silver then acts as a nucleus in development. At first it was thought to be free metallic silver, but this did not agree with the great resistance of the latent image to nitric acid, for example, so that the theory was later modified by Abegg by supposing that the silver is present as colloidal silver which is adsorbed by the silver halide. This idea has been especially developed by Lüppo-Cramer, and it has been shown that synthetic adsorption compounds of colloidal silver and the silver halides behave towards chemical reagents very similarly to the latent image and the photohalides. The facts of physical development support the idea that silver is present in the latent image.

A modification of this idea is based on the fact that the sensitivity of high speed emulsions can be more or less destroyed by the use of certain oxidising agents before exposure. It is supposed that during the preparation of the emulsion incipient reduction of the silver halide by the gelatin takes place, and that the traces of colloidal silver so formed act as a catalyst for photochemical decomposition; such catalysis is supported by the experiments of Fajans. Renwick has suggested that these traces of colloidal silver are in such a state that they cannot act as nuclei in development; the action of the light is to bring about their coagulation to such a coarse condition that the aggregates so formed can act as nuclei. Although there is evidence that light will coagulate suspensoid sols, it is somewhat difficult to postulate coagulation in a medium such as that of the silver halide grain.

In referring to the chemical theories nothing was said as to the mechanism of the action whereby the silver is set free by the light. The chief argument brought against a chemical theory has been that the incident energy necessary to make a photographic plate developable is insufficient to produce any appreciable decomposition. This argument may be valid if a straight decomposition of the silver halide is considered, but it probably does not hold if applied to the transfer of electrons when influenced by adsorbed material in some such way as that postulated by Fajans.

If it be conceded that the latent image does consist of silver in some form or other, the question still remains to be answered as to what constitutes the sensitivity of the photographic grain, since it is this sensitivity which gives rise to the formation of the latent image on exposure. The first point to be considered is this: when a plate is exposed and developed under ordinary conditions, an image is formed because there is more blackening, that is, a greater density, in some places than in others, or, in other words, the amount of silver deposited varies in different parts of the plate, according to the exposure. Is this variation in the amount of silver due to every exposed grain having become developable, but only a definite fraction of the grain being reduced to silver on development, the fraction being all the greater the greater the exposure, or does only a certain percentage of the grains, depending on the exposure, become developable, each developable grain being reduced completely to silver, but not communicating its developability to contiguous grains? This question can only be answered by experiment, and the accompanying Fig. 16, which depicts developed grains (black) in contact with undeveloped

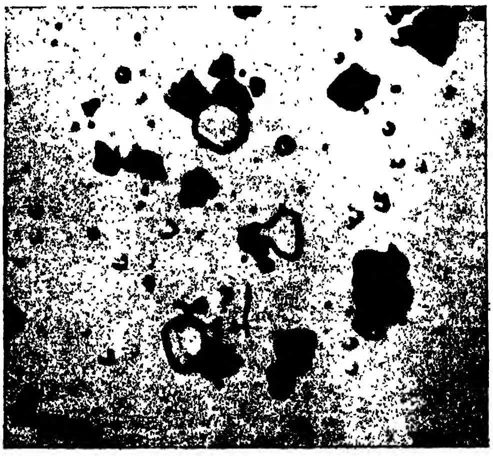


Fig. 16.

grains, shows that it is the latter process which occurs. However, it should be mentioned that in some emulsions clumps of grains occur, and Sheppard and his co-workers maintain that when one grain in the clump becomes developable the whole clump develops.

It follows from the above that the individual grain is the fundamental unit, and the question immediately arises as to why, on exposure, a change occurs in different grains at different times. The answer might be that in a photographic plate there is not a single layer of grains, but many layers; the upper layers act as a screen to the lower ones and the extent of penetration of light will then depend on the exposure. Prof. Svedberg, of Upsala, found, however, that when a plate contained such a thin coating that there was only a single layer of grains, all the grains were still not changed simultaneously. He then suggested that the difference in behaviour might be due to variation in size of the grains, but further experiments proved that this suggestion was not correct. Independently, and at about the same time, Slade and Higson, of the British Photographic Research Association, came to the same conclusion, and since then Dr. Toy, of the same Research Association, has investigated grains which, in shape and size were as nearly identical as possible, and proved conclusively that some required roughly two hundred times as much light energy, incident on unit area of the plate, as others, in order to make them developable.

Further investigation has shown that on each grain there seem to be certain "centres" from which development starts. Chapman Jones, in 1911, showed that by stopping development almost immediately after it was started, particles of silver had been formed in the grain; these could not be observed microscopically until they had been enlarged to visible dimensions by deposition on them of mercury. In 1917, Hodgson, in America, showed that by stopping the development at a somewhat later stage, silver could be observed at certain points only in the grain. Then Svedberg, in 1922, working along similar lines and using an emulsion with spherical grains, proved conclusively, in a very ingenious manner, that these centres occur on the surface of the grain. Further evidence of this has been obtained by Toy, using emulsions in which the grains were flat plates; as shown in the diagram, (Fig. 17), the centres occur mostly at the edges of the plates, as would be the case if they were on the surface.

It might, of course, be said that the occurrence of these centres on the surface is simply a development phenomenon, due to the greater solution pressure which occurs at irregularities of the surface, and especially at the edges of crystals. This objection has been raised by Mees, and has been considered by Toy, who has shown conclusively that the phenomenon in question does not play a part. Moreover, it would be absurd to assume that the change due to exposure is localised in the grain and yet that the local action of the developer was not at the points where

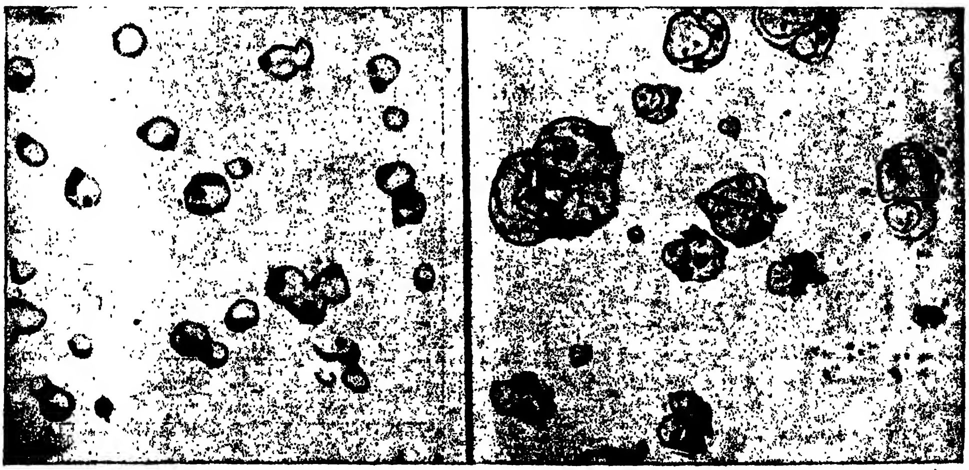


Fig. 17.

the change had taken place, for if this were so there is no reason why exposed grains should act differently from unexposed grains. Again, the number of centres increases with the exposure and it is difficult to avoid the conclusion that their localisation agrees with that of the sensitive material which is the precursor of the latent image.

Painstaking and exacting measurements by both Svedberg and Toy have shown that these centres are distributed among the grains entirely haphazard, according to the law of chance. This law states that the chance (P_r) of the distribution of N centres between a grains resulting in any one grain having r centres is

$$P_r = (N/a)^r e^{-N/a} / r!$$

and this equation has been found to correspond with the results obtained by direct counting of the centres.

Different views are held at present as to how these centres are formed, and Toy has summarised them as follows:—

(1). The centres are formed in homogeneous grains entirely by light which is incident at points on the plate in finite discrete quantities.

(2). The centres are pre-existent in the grains before exposure as a chemically different substance, the function of the light being to change their condition in such a way that they become capable of acting as reaction centres. The light is considered as acting equally on all grains.

(3). A combination of (1) and (2), that is, heterogeneous radiation is incident on grains containing specially light-sensitive points.

These various views may be considered separately.

(1). This view has been developed by Silberstein, of the Kodak laboratories, and investigated experimentally by other workers there. Mees states the matter simply, as follows:—"If we had no prior knowledge of the wave theory of light, it is clear that the simplest explanation of the sensitiveness of different grains would be that, instead of a continuous flow of light in the form of waves on to a sensitive plate, the light was falling upon it as a rain of projectiles and that these projectiles made developable any grains that they hit, the grains that they missed not being developable but being hit later if they continued to be exposed to the radiation. Naturally, the bigger the grains the more likely they are to be hit, so that a calculation, based on the probability theory, can be made of the relation between the size and the percentage number of grains which will become developable after a given exposure." Silberstein suggested that these projectiles are discrete light quanta and called them "light darts", each one being imagined to consist of a long train of waves of very small diameter travelling with the velocity of light.

In the above assumptions there is nothing relative to the occurrence of centres in the grains. The only postulates are the "light darts", the area, or rather the projected area of the grains, and a haphazard hitting of this area by the light darts. From these postulates Silberstein developed the equation

$$k/N = 1 - e^{-na}$$

where a is the projected area of the grain, k the number of grains hit, N the total number of grains per unit area, and n the number of light quanta impinging on unit area. This equation indicates that the chance of a grain becoming developable increases very much with the size, a result which had been previously obtained by Svedberg.

Trivelli and Righter have submitted this equation to the test of experiment and claim to have verified it. Unfortunately the test was not made on single grains, but on clumps of grains, the number of grains varying in the different clumps and hence the projected area varying. For the particular emulsion used it was proved that each clump acts as a single grain as far as developability is concerned. The reason for using clumps was that thereby a much bigger variation in the area could be obtained. The results of three of their experiments are shown in (Fig. 18) by the

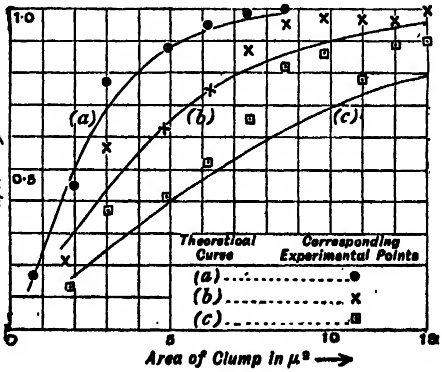


FIG. 18.

marked points, the theoretical curves being the continuous lines. It will be seen that only in one case is the agreement fairly good. There is certainly room for doubt whether these experiments really support the theory. Toy has tested the equation for sets of equal-sized grains and found that it breaks down completely.

If it were true that the grains were really subjected to bombardment by discrete light darts, the centres already mentioned would represent their points of impact. In that case, however, the centres would be distributed, on the average, equally over the projected area of spherical grains and not equally over the surface, and in the case of flat plates the distribution would be equal over the surface and not concentrated at the edges. The actual topographical distribution of the centres has already been mentioned ; it is not in accordance with the demands of the light dart theory as given in (1).

(3). It will be convenient to deal with (3) before (2).

Work carried out by Leimbach, and the results of some preliminary experiments done in the Kodak laboratories, indicate that for high speed emulsions several hundred quanta of light are necessary per grain in order to make the grain developable. This would make a simple light dart hypothesis insufficient, and consequently (quoting Mees) "we are thrown back on the idea of differential sensitiveness among the grains, or of spots of limited area on the grains, so that of the hundreds of quanta striking a grain only one may be considered to be operative, the rest falling upon the insensitive portion of the grain." This modification of the original thesis thus admits the possibility of heterogeneity in the grain and, therefore, of "centres." Its mathematical consequences, in conjunction with the idea of "light darts", have been worked out by Silberstein. A crucial test, however, may be applied as follows :—A plate is exposed to a beam of monochromatic blue light for a given time and the percentage of grains changed, that is, made developable is ascertained. A similar experiment is done with a beam of monochromatic violet light, using the same intensity, as measured by the thermopile, and the same time of exposure. Since the frequency of violet light is greater than that of blue, the number of quanta received by the plate for equal times of exposure and equal incident intensity will be more for the blue than for the violet ; that is, under proper conditions blue light should cause a greater percentage of grains to be changed than will violet light. Toy has shown, however, that the opposite is the case, so that the assumption of light darts does not predict results which are in accordance with experiment. Thus, at present, both (3) and (1) seem to be ruled out of court.

(2) has now to be considered. Is there any chemical evidence for an heterogeneity of the grain which would indicate the presence of sensitive spots which are pre-existent to light action?

It has already been mentioned that a solution of sodium arsenite acts on the plate in a way similar to light, that is, it makes it developable. Clark, working in the laboratories of the British Photographical Research Association, has shown that when a plate which has been immersed in this solution for a suitable time is partially developed, the centres from which development starts are not only distributed amongst the grains according to the same law of chance as holds when the exposure is to light, but that they have exactly the same topographical distribution, that is, both the light and the sodium arsenite appear to act on the same points in the grains. Further chemical investigation indicated that the substance forming the centres could not be silver bromide. Now if the sensitivity of the grains is chiefly due to this substance, it follows that if it is removed the sensitivity will be reduced to that of pure silver bromide. Naturally this can be best tested on high speed emulsions, and to apply the test, Clark made use of the well-known fact that the latent image, that is, the product of light action, can be removed by chromic acid. Two pieces, A and B, of a highly sensitive plate were taken. A was exposed to an intensity such that, if developed, all the grains would be changed, that is, all the specially sensitive points would be affected. A and B were then placed together in a solution of chromic acid, without developing A. After being thoroughly washed and dried A and B were exposed together in the ordinary sensitometric apparatus used for measuring the sensitivities of plates, and it was found that B was always more sensitive than A. The plate sensitiveness was not reduced to zero, but to the same constant value for all plates, which probably corres-

ponds with that of the silver halide itself, Two examples of the results obtained are given below.

1. (*a*) Sensitiveness of the untreated plate =215
   (*b*) Sensitiveness after treatment with N/20 chromic acid for 7 minutes = 68
   (*c*) Sensitiveness after treatment with N/20 chromic acid for 7 minutes after a preliminary exposure of 8 seconds =5.

2. Using N/50 chromic acid instead of N/20, the respective sensitivities were: (*a*) = 215, (*b*) = 105, (*c*) = 5.

It is known that the sensitiveness of a plate is reduced by merely bathing it in chromic acid without preliminary exposure, but even bathing it for one hour will not reduce it to the low value obtained in the above experiments after a preliminary exposure. This is illustrated in (Fig. 19).

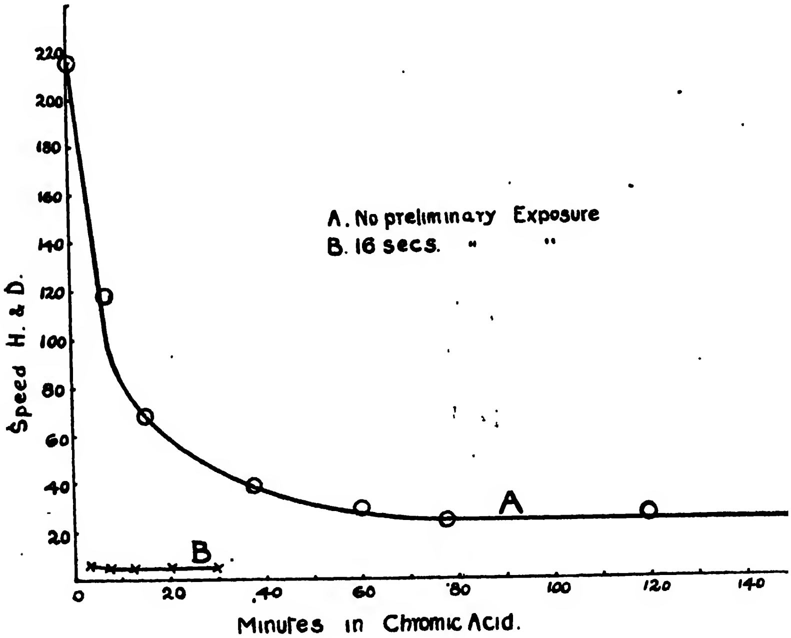


Fig. 19

Increase in the preliminary exposure, past a certain minimum value, for a given time of immersion in chromic acid, does not bring about a corresponding decrease in sensitivity.

Similarly Clark has found that treatment with chromic acid solution readily and completely removes the "latent image" formed by the action of sodium arsenite, whereas the sensitivity to sodium arsenite is only slowly reduced by immersion in chromic acid. It follows that the product of the action of light (and of fogging agents) on the plate is much more readily attacked by chromic acid than is the sensitivity-giving material itself, although this latter is slowly attacked.

From the above there seems to be no doubt about the validity of (2), that is, that the extreme light sensitiveness of the silver halide of the photographic emulsion is primarily due to the presence of minute traces of some other substance. The question has still to be answered as to what this substance is. Clark has endeavoured to find an answer by the application of the results of Fajans' work to a consideration of the fogging action of hydrogen peroxide and ozone. On the assumption that the sensitive substance consists of OH-body he was able to give a better general explanation than has previously been put forward of the apparently very contradictory observations made in this connexion. Fajans and Frankenburger showed, as already stated, that the OH-body behaves in such a way that it seems as if an electron is readily transferred from the OH-ion to the Ag-ion, with the formation of silver nuclei, that is, the hydroxide body behaves as if it were silver hydroxide. Now it is well known that silver oxide readily reacts

with hydrogen peroxide and ozone, giving silver, and presumably silver hydroxide would act in the same way. Thus the action of the peroxide on the plate would give silver nuclei which would act as development centres and give rise to fogging.

The explanation of sensitivity cannot, however, be as simple as this, since the phenomena observed are very various and extremely complicated. For example one is immediately met by difficulties when an attempt is made to apply the hydroxide body theory to Clark's results with chromic acid. It would be expected that the OH-body would be destroyed more readily by the chromic acid than the silver nuclei formed from it on exposure, whereas the opposite is the case. At present, however, our exact knowledge of the effect of adsorption on chemical reactions is so limited that it is not necessary further to discuss the matter.

So far mention has only been made of sensitive centres on the surface of the grain. In addition to these, however, there seem to be internal nuclei present in the grain. The evidence for this is given by Lüppo-Cramer's work on "Keimblosslegung" or "nucleus exposure", which may be illustrated briefly as follows. The surface latent image on two equally-exposed lantern plates was removed by treatment with a chromic-sulphuric acid mixture (cf. Clark's experiments); after washing out thoroughly the chromic acid, one of the two plates was bathed for 30 seconds in a one per cent. solution of potassium iodide and then developed in the same physical developer as the other. The plate treated with iodide showed, after three minutes, the whole of the scale in a Chapman Jones sensitometer, whilst the control plate gave no image after 30 minutes. An explanation of this is that when the silver bromide grain is transformed into the iodide it is broken up into a number of finer particles—this has been confirmed by Renwick and by Sheppard, Wightman and Trivelli—and that thereby internal nuclei of silver are laid bare and initiate the process of development. Lüppo-Cramer, in his book on "Kolloidchemie und Photographie" gives an explanation to the effect that the adsorption compound of silver with silver iodide is less stable than that with silver bromide, and that therefore the nuclei are rendered more active. This is in accordance with the known stabilities of the photohalides, whereas with silver ions the adsorption increases in the series $AgCl \rightarrow AgBr \rightarrow AgI$. Whatever the explanation may be, by transformation into iodide the grain is apparently opened up in such a way that nuclei are laid bare to the action of the developer.

These experiments show that after exposure to light there are present internal nuclei from which, after being laid bare, development can proceed. They do not show whether the nuclei, or sensitive centres from which the nuclei are formed on exposure, are pre-existent in the unexposed grain. Some recent experiments of Sheppard, Wightman and Trivelli contribute something towards the solution of this problem. Single layer plates were treated with various reagents, washed, dried, exposed and chemically developed. When the pre-treatment was with potassium iodide, or with chromic acid followed by potassium iodide, the sensitivity was reduced to about 1/512th, part of the original value; treatment with chromic acid alone to remove the surface sensitivity, gave a reduction to about the 1/32nd part of the original speed. When, however, the treatment was with chromic acid, then with potassium iodide, and again with chromic acid, the sensitivity was destroyed to such an extent that 16,000 times the normal exposure would not give a developable image. Thus, opening up the grain with potassium iodide, after the external centres had been removed with chromic acid, laid bare sensitive centres which, on exposure, gave rise to a latent image, since development took place. Further treatment with chromic acid, however, removed these sensitive centres, and exposure did not recreate them or give rise to nuclei.

These experiments do not show what is the nature of these internal sensitive centres in unexposed grains, but simply indicate their existence. They may be similar to the surface centres, but do not come into play during the process of ordinary development, being imbedded in the grain. They may, on the other hand, consist of silver nuclei formed by incipient reduction of the silver bromide by the gelatin, the nuclei acting as a catalyst to photochemical decomposition during exposure. Further experiments are necessary, but with the present evidence there does not seem to be any need for ascribing a different nature to the internal and superficial sensitive centres.

The foregoing will, I think, indicate the difficulty of the questions of the latent image and of sensitive centres. This difficulty is further enhanced by the fact that the only method of showing the presence of the latent image and centres depends on the use of developers, which, of themselves, act in different ways. Questions of adsorption, etc., of the developer arise, but these cannot be entered into here.

Supposing that the nature of the sensitive centres and of the latent image were definitely settled, it would still be necessary to know the energy changes involved, that is, the amount of light energy absorbed by a single grain in order that a centre may be produced. Very little work has been done in this connection; the "print-out" effect has been studied to some extent, but the energy there involved is of quite a different order from that required for the formation of the latent image. The main difficulty lies in the measurement of the amount of energy absorbed by the grain. There remains, however, the possibility of measuring the relative amounts of energy absorbed when exposure is made to equal incident intensities of monochromatic light, as measured by a thermopile, and some preliminary experiments in this direction have been made by Toy. Slade and Toy have measured the absorption of fused silver bromide for the blue, violet and ultra-violet lines of the mercury vapour lamp, with wave lengths 4358, 4062 and 3650 Å.U. and found the ratios, neglecting reflection, to be 1 : 3.3 : 12.2. Now Wilsey has shown that the crystal structure of the salt which has been fused and allowed to solidify is the same as that of the grains in an emulsion, and therefore if the small size of the grains does not introduce any appreciable error, the greatest effect should be obtained with the ultra-violet and the least with the blue. Actually, the ratio of the number of centres produced was found to be 1 : 3 : 10.9.

If the absorbed energy is calculated, not in the same units for all wave lengths, but in terms of quanta, the theoretical ratio is 1 : 3.1 : 10.2, which is in very good agreement with the experimental value.

These results are shown in Fig. 20. which at the same time shews the curve which should be obtained if the "light dart" theory were true. Toy suggests that since they have been obtained on the assumption that silver bromide is the absorbing material, they indicate that this is the substance actually involved in the formation of the latent image. The function of the traces of

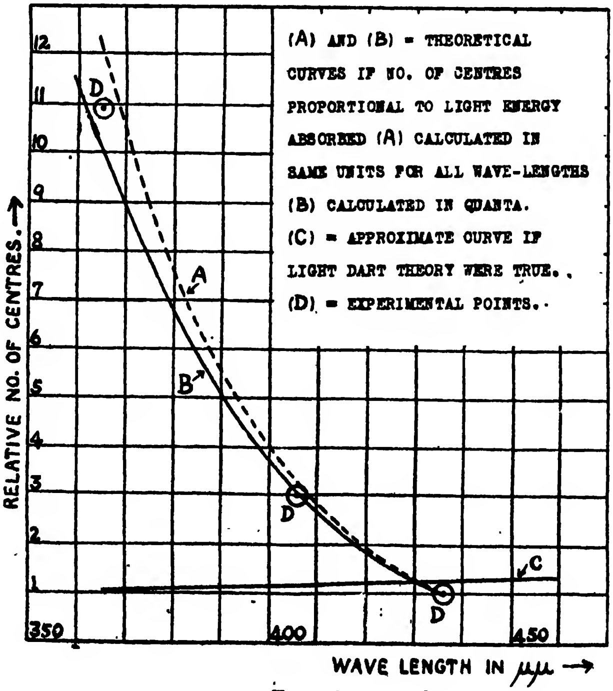


FIG. 20.

foreign matter, that is, of the adsorbed material, will then be to accelerate catalytically the photo-decomposition of the silver bromide. This would, of course, be in agreement with the ideas of Fajans. Much further experiment, however, is necessary.

Figs. 2, 3, 4 and 7, in Dr. Slater Price's course of lectures have been reproduced, by kind permission of H.M. Stationery Office, from the Descriptive Bibliography of Gelatin, published as Appendix 1. one of the First Report of the Adhesives Research Committee. The Society is also indebted to the *British Journal of Photography* for Figs. 8, 9, 11, 12 and 13; to *Science Progress*, published by Mr. John Murray, for Figs. 16, 17 and 18; and to the Faraday Society for Figs. 19 and 20.

NOTES ON BOOKS.

ORIGIN AND HISTORY OF ALL THE PHARMACOPEIAL VEGETABLE DRUGS, CHEMICALS AND PREPARATIONS, with Bibliography. Volume I, Vegetable Drugs. By John Uri Lloyd. Prepared under the auspices of and published by the American Drug Manufacturers' Association, Washington, D.C. Cincinnati: The Caxton Press.

The present volume is the first of the latest revision of a work which in its various stages has been recognised as one of increasing national importance in the United States.

It would seem that the mantle of our great pharmacologist, Dr. Pereira, has fallen on Dr. Uri Lloyd, a like spirit of the enthusiast and the zealot characterising both; thus the book becomes delightful to read and so technically important that no pharmacist, medical practitioner, general import merchant, or wide-viewed student, can afford to ignore it.

Only vegetable drugs are considered in Dr. Uri Lloyd's volume; chemical products coming under study in a second volume written jointly by Dr. Waldbott and Professor Heyroth.

The photographic illustrations, by Mrs. John Uri Lloyd and others, are 53 in number, and are printed on enamel paper as 28 inset plates; the first of these coming under the first cover, and so being anterior to the title page. The first photograph shows the two Ionic columns partly imbedded in the tangle where wild poppies and liquorice now grow: this being all that is now to be seen of the eighty columns which once graced the temple of Rhea or Cybele, the reputed mother of the Greek gods, and whose chariot we are told was drawn by four lions: indeed, all that now is to be seen of the richest city of old time, the renowned Sardis, the seat of the vast empire of Crœsus. In our author's note opposite this photograph, he concludes by asking what flowers of the field may one day trail over the buried glories of present time civilisation.

The East, which has given us the names and materials of so many vegetable drugs, comes to sight in the plate opposite p. 152: one photograph showing Turks digging liquorice root in the valley of the Meander, an old Roman road stretching across the background; and the other photograph showing the liquorice diggers at lunch, with the liquorice tangle as a background. Turning over a leaf we find two more views showing the valley of the Meander, so noted for wild liquorice; one of these photographs, includes the picturesque rock of Niobe on which is sculptured a prehistoric figure of the sorrowing mother. Rhubarb (p. 267) is an example of a Galenical originally from the Far East (China) as is more or less recognised by its name "*Rheum barbarum*," although by shifts and changes of meaning this term drifted to rhubarb from the Levant, and on p. 270 one may read the romance of rhubarb and the high prices arising from land transit over the breadth of Asia; for example, more than four times the price of saffron (in France, 1542).

Obviously, we cannot trace the general drift of sources from the Far East to the New World and the return gift of New World drugs to the East, as exemplified by the romantic story of Peruvian bark from its first use to the time of its cultivation in British India, pp. 62-63. Next following is a remarkably full and well-illustrated account of the uses and abuses of coca (the divine plant of the Incas), pp. 84-103, with three plates. In reading this account one cannot help feeling regret that humanity is so often deprived of the desirable and useful, by reason of misuse by the degenerate.

Scammony (p. 297) and Jalap (p. 176), give us an example of partly similar drugs: one from the East and the other from the West. Pharmacologists of antiquity, as Theophrastus and Dioscorides, also middle age writers, fully recognise the value of scammony as a drug, and the eminent Mynsicht, to whom the discovery of tartar emetic is generally attributed (see Watts's Dictionary of Chemistry, 1st ed., Vol. V, 1868, p. 648), after a general note on the merits of scammony, gives details as to the preparation of *Magisterium scammonii*, a precipitated resin of scammony and perhaps the earliest example of the isolation of the active principle of a vegetable drug. Details are given by Mynsicht in a late (third) edition of his *Armamentarium Medico-Chymicum*, a volume of 530 pages (of which 40 pages consist of index matter), published at Venice in 1696, but the West has given us in abundance and at a low price the active principle isolated by Mynsicht, it being a chief constituent of some kinds of jalap, especially of the so-called spurious jalap (*Ipomoea simulans*). Mynsicht's volume represents the views and practice of the Paracelsian School, or Spagyrists, as they termed themselves; and not only pharmacy, but also chemistry owes much to this school, so that a *fac-simile* reproduction of the text of Mynsicht's representative volume would probably be of use to those interested in the historical or the technical aspect. Owing to peculiarities

in the text neither a reprint nor a translation would have the value of a *fac-simile.*

To return to Dr. Uri Lloyd's book, now under notice, the style is so good, so clear, pleasant and non-pedantic, with illustrations so telling and attractive as to make it eminently suitable for a reading book in schools.

TUTENAG AND PAKTONG: with notes on other alloys in domestic use during the eighteenth century. By Alfred Bonnin. Oxford University Press, Humphrey Milford.

This *édition de luxe,* in quarto, on Abbey Mills paper and with 29 plates at the end, is a remarkable and comprehensive study of the white Chinese alloys, their constituents, their uses, their history, and of the early attempts to manufacture them in Great Britain.

On page 45 our author points out that the general term in English should be "nickel brass," not bronze, the modern use of the term bronze indicating the presence of tin; or as we should prefer to define the matter, the presence of tin that functions as an effective or leading constituent; traces being left out of consideration.

Mr. Bonnin has exercised remarkable industry and skill in searching out historical details relating to nickel brass, its constituents and its part-parallels in industrial and artistic metallurgy.

The central area or display field of this delightful work is the latter half of the eighteenth century when British manufacturers made many articles of domestic use with the white alloys for which China has long been celebrated, and the white Bactrian coins mentioned in Mr. White's recent booklet on nickel (see *Journal* for April 27th, 1923, p. 413) rather suggest that the export of nickel brass from China has been carried on for considerably over two thousand years. Unfortunately, we have scarcely any records of the Bactrian industries, but it seems reasonable to conjecture that the Bactrian coins mentioned in Mr. White's book and commented upon in our columns, were made of alloy imported from China and consisting mainly of copper, four-fifths; nickel, one-fifth.

On page 41 of Mr. Bonnin's book we find an interesting account of Mr. Thomason's experiments at Birmingham, in 1823, on the imitation of the Chinese white alloy; the nickel addition to impure copper (copper to which iron had been purposely added) being in the form of the crude nickel of that time; a product very different from the almost chemically pure nickel of our time as prepared by the Mond process.

This alloy did not prove in all respects satisfactory, especially in respect to soldering, so active experimenting was discontinued, and some six years later a similar alloy was introduced into Great Britain from Germany; hence the term "German silver."

There is a temptation to linger over all the interesting quotations relating to the white brasses or nickel brasses, which Mr. Bonnin culls from our chemical sources of the past two centuries, but this is impracticable, and perhaps we may conclude with a note of sadness which often arises in the mind of the modern disciple of Vulcan (the metallurgical chemist), when he finds matters of keen interest to himself in an *édition de luxe.* He feels he requires three copies; one for careful preservation, another for his laboratory bench with a pencil on the open book, and still another which he can cut into slips for insertion into other books. If the purely technical matter and references to authorities of works like the present could be purchased in cheap pamphlet form, our modern chemist, the Tubal-cain or Vulcan of our day, would not feel this slight tinge of sadness in reading a delightful book.

WAX FLOWER MAKING IN VICTORIAN TIMES.

BY MARY SCOTT.

Of the many ways in which the 20th Century misunderstands the 19th, the present-day contempt for the gentle art of Wax-flower making is a notable (if minor) instance, and suggests how very active the historical imagination needs to be, if we are to comprehend aright the more distant past, when there is so much gross incomprehension of conditions obtaining a mere generation or two ago. Almost without exception, in conversation or in cold print, it is taken for granted that Wax-flowers touched the high water mark—or low water mark—of Early Victorian futility. Probably this disdain for an originally dainty art is due in part to the fragility of the material used (fine sheet-wax), and the consequent dilapidation of such flotsam and jetsam as may have lingered on to comparatively recent times, lurking in odd corners of a sea-side lodging or a country inn in ever dustier disrepute.

In reality, not only did the processes of Wax-flower making require considerable artistic ability, but botanical accuracy was a *sine qua non*; the correct reproduction of the character of the anthers for instance, as well as of such hidden details as the modelling of the base of a pistil, being matters of course. Actual flowers and leaves were carefully studied and the impress of the veining was transferred, when possible, from the living leaf to its waxen double. In schools where girls in the advanced classes were taught Wax-flower making, the subject was definitely connected in the curriculum with precise and accurate (though perhaps limited) botanical instruction, and the seeds of Nature lore were sown more than half a century before Nature study was boomed as the latest advance in education. It is well to remember facts like these before echoing the cheap and wholesale accusations of "artificiality" with which it is the fashion to label the Victorian era. There was certainly no element of pretence or deceptive intention in the making of Wax-flowers; they were wrought in all sincerity as

faithful representations of floral nature and symbols of its beauty.

A further count in the indictment of the Wax-flower-maker's art lies in the too frequent combination of incongruous varieties—in season or out of season. It was a day of individualism, and it was each separate, individual blossom that was valued for its intrinsic colour or form—"massing" in decoration being an unknown canon of taste at that date. It may be argued indeed, and not without plausibility, that Nature herself uses a mixed palette much more often than she indulges in the complete "colour scheme" of a field of buttercups or a woodland drift of blue-bells

It was some time in the later sixties that the writer, as a child, was presented with a certain finely japanned Wax-flower maker's box, its partitions filled with fascinating sheets of sweet smelling wax, white and coloured, and all the various implements formerly owned by the giver It was a breathless moment when eager fingers were first instructed in all the delicate processes and a "garden pea" winged in purple and pink reality, at length emerged! It may be noticed in passing that the paper patterns, (cut from the actual petals) in the old box are on a distinctly smaller scale than the flowers of the present time, and this same pea-blossom, life size in its own day, would be deemed a very poor and feeble bloom now

It is the easy possibility of flowers in profusion all the year round that has long ago killed the desire of having them always with us in effigy. But if we "think back" to the conditions of life before say, 1850, when Wax-flowers flourished in their fragile prime, we may in a measure realise the value that any even passable representation of living flowers must have had in a world bereft of them for six months in every twelve. In the days of that old iniquity the window-tax,, only the rich might, in orangeries or pineries, keep a few special plants alive from season to season. But the older orangeries were little more than long stone galleries with large south windows and solid walls and roofs with flues in the walls for heating purposes. No conservatories: no greenhouses as we now know them: no florists' shops: no yearly influx of bulbs from Holland. Some few horticultural and nursery gardens there were, which would supply for perhaps 5/- the meagre half-handful of mixed blooms that, with fruit in addition, was (at least in the provinces) deemed sufficient decoration for the formal dinner party as late as the sixties and earlier seventies. On less important occasions, carefully polished apples and oranges, and other dessert fruits, decked with bay, laurel, or holly leaves (if one grew bay, laurel or holly) sufficed, while the ordinary daily dinner-table of our great grandmothers' young days was chastely furnished forth with its central cruet alone. The ceremonial silver and gilt epergnes of the period were usually devised for the lower tiers to hold fruit, terminating in a tall, narrow vase for a few precious blooms at the summit of all.

It was, of course, mainly due to Sir Joseph Paxton that all this was changed—and rapidly changed—when once the great Exhibition of 1851 with its "Crystal" Palace had familiarised people with glass-building and its possibilities. The remainder of the century saw the rise of glass in all its garden uses. but with the advent of the 20th century professionalism had already stepped in, florists had multiplied, and private people began to realise that it was both easier and cheaper to buy forced flowers than to grow them In addition to this, the pre-war tendency was increasingly in favour of house tenancy rather than ownership, and although since the war this condition has been reversed, the adding of glass-houses to the white man's other burdens is hardly likely to take place on any considerable scale in present circumstances. In the future we seem likely to depend more and more on the florists for winter flowers, using our summer gardens to grow our own favourites or to follow the cult of the moment.

In the winters of the writer's earliest recollections hyacinths were sometimes grown in water in special glasses, but in no great number or variety. In the summer things were better; but even in summer no gardenless folk had, or could obtain, cultivated flowers save by grace of friendship, and to those who had gardens, the earliest snowdrop and the first rosebud had an intensity of welcome and brought an intensity of delight, that is to-day quite unimaginable. Possibly in this fact lies some explanation of the undue fondness of our forebears for "natural" leafage in woodwork and ironwork, and even some atonement for their reckless indulgence in elaborately floral carpets and Berlin woolwork roses. However this may be, if we can conjure up the formal rooms carpeted all over; the good but massive furniture; heavy hangings; large and few pictures; and breadth of simple colouring unrelieved by any lighter touches, and at night time indifferently illuminated by gas or candles—then it becomes perhaps more possible to grasp the fact that they (our great-grandmothers aforesaid) were not entirely given over to idle folly, when they fashioned with delicate, loving touches, their marvellously accurate representations of the flowers they loved so well but could enjoy so briefly. They even loved them enough to prefer having them in wax and under glass shades, to foregoing them altogether. In the same spirit, exiles under tropic suns have been known to cherish a forlorn English daisy in a flower-pot!

(N.B.—The Wax-flower making box referred to above is now in the South Kensington Museum.)

MATCH PRODUCTION IN LATVIA.

The manufacture of matches in Latvia assumed considerable importance during 1923 as an export industry. At present there are six match factories operating in the country, producing an aggregate of 1,000,000 boxes of matches daily. Of this output 75 per cent. is exported, principally to the British market. Four of these plants are of major

importance, employing approximately 750 men and producing close to capacity. The smallest is the only one utilising modern match-making machinery, so that the industry is still characterised by old equipment and methods. Movements are afoot, however, to modernise the industry.

From a report by the Secretary to the United States Trade Commissioner at Riga, it appears that the daily output of match splints for export from the six factories in operation reaches about 125,000,000, practically all of which is exported chiefly to England, Holland, Belgium, and Switzerland. With the expansion of the match-making industry in Latvia it is probable that the Government will protect it by planting uncultivated forest land with aspen timber—vigorously preserving present stands—and by prohibiting the export of match wood.

PRODUCTION OF ABACA IN THE PHILIPPINES.

The production and exportation of abaca, or manila hemp, were considerably greater in 1923 than in the previous year. There is no basis for an accurate estimate of the consumption of this product in the Philippine Islands, but the Manila Chamber of Commerce places the output of the local rope factories at approximately 24,000 bales, or about 3,000 metric tons. The method of estimate, however, is arbitrary, and it is possible that there is a considerable variation between this figure and the actual amount consumed.

According to a report by the United States Trade Commissioner at Manila, the rope factories are turning out a fairly large amount of cordage, but they are, for the most part, unwilling to give their production figures. The exports of rope, which totalled 2,631 metric tons in 1922 and 3,160 in 1923, consisted chiefly of cordage manufactured from maguey.

The best indication of the activity of the industry, and by far the most important phase of the trade, is the exportation of manila hemp, which amounted to 190,441 metric tons, valued at 49,903,150 pesos (peso at par = 2s. 1d.) in 1923, as compared with 172,026 tons, valued at 39,081,828 pesos, during the previous year, and 100,401 tons, with a value of 25,969,385 pesos, in 1921.

In the Manila market abaca is roughly classified into three main groups: US (United States) grades, UK (United Kingdom) grades, and those which are used both in the United States and the United Kingdom. The grades predominating in the United States, generally called United States grades, are A, B, C, D, E, F, and I, and those exported both to the United States and England are S1, S2, S3, G, H, and J1. Grades A, B, C, D, and E are used in the United States for making the higher-grade rope, such as is required for yachts, the United States Navy, and other purposes for which a specially good quality is needed. F and I are the staple grades in the United States for the rope used in the merchant marine. Other rope grades are D, E, and F, S1, S2, J1, G, S3, and H, all of which are used in varying proportions in order to level the quality and colour for the various grades of rope manufactured. The grades used in the United States for making binder twine are S1, S2, J1, G, S3, H, and sometimes I. Grades G, S3, and H, while of good quality, are of a more or less dark colour, and a considerable portion of these lower grades is made up into yarns which are tarred. Colour, therefore, is not a selling factor. In the customs returns, grades J1 and J2 are returned under the general name of J.

The following table shows the exports of the principal classes of abaca to the United States for the years 1920 to 1922:—

Grades	1920	1921	1922
	Kilos	*Kilos*	*Kilos*
A	52,626	25,554	84,884
B	154,047	83,238	215,053
C	884,490	271,724	802,647
D	2,448,107	994,043	2,129,639
E	7,290,710	3,386,788	5,103,268
F	14,297,484	9,082,450	17,126,982
I	17,704,800	9,689,631	22,895,871
S1	2,262,697	1,333,893	4,167,202
S2	3,543,999	1,355,324	6,914,115
S3	1,493,588	836,169	2,757,451
G	2,520,682	1,150,392	6,448,274
H	1,324,990	565,457	1,761,895
J	11,094,808	5,452,417	11,886,703
K	411,381	122,706	415,049
L	648,316	39,215	227,323
M	133,459	56,925	2,657
DL	1,771	——	2,657
DM	——	——	1,898
Allothers	773,814	112,461	601,359
Total	67,041,769	34,558,387	83,544,927

GENERAL NOTE.

MOTOR TRANSPORT IN BULGARIA.—There are approximately 4,000 miles of roads in Bulgaria, and even before the war the best of them were no better than the average English second-class road. Now, owing to lack of labour and capital, all roads in Bulgaria, judged from English standards, are bad. According to the report of the Secretary in charge of Commercial Affairs at the British Legation, Sofia, the usual method of transport is the ox-cart, but since the war motor transport has made a small but steady headway, and there are now some 900 touring cars and 400 lorries in the country. There is a demand for a cheap touring car, capable of holding six people, and which shall be strong enough to stand the road conditions. At present, there are not more than half a dozen British cars in Bulgaria. As, however, old motor stock which came into private ownership on the conclusion of the war becomes worn out, there will be a steady demand for replacements, and British firms which could compete in price with popular Continental makes would find an opening in the country.

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

A STUDY OF THE DESTRUCTIVE DISTILLATION OF COAL.

By Edward Victor Evans, O.B.E., F.I.C.,
Chief Chemist and Products Manager, South Metropolitan Gas Company.

Lecture I.—*Delivered February 25th,* 1924.

It is with considerable temerity that the author addresses you on the subject of the destructive distillation of coal, and his ability to do so may be open to just criticism in view of the fact that his first-hand experience in these matters is confined to the carbonisation of coal in horizontal retorts, and does not comprise the working of vertical retorts and the manufacture of water gas. It is proposed, however, to deal mainly with the principles underlying the process of carbonisation, and it is believed that these do not vary so fundamentally in the different systems that these lectures will fail to render some service to the gas and allied industries.

In the Cantor Lectures of 1919, Prof. Bone dealt in a comprehensive way with the general question of coal conservation, and the author desires, though perhaps in a less direct manner, to make a further contribution to this subject mainly from the view-point of a chemist in the gas industry. It is proposed in these lectures to regard the destructive distillation of coal as a true chemical process, the raw material being the therms constituting the potential heat energy of the coal, while the process itself consists in the distribution of this energy into more useful and more economic forms.

The introduction of the therm system met with a cold reception at the hands both of the public and of the gas industry, but to-day this has given place to a quiet acknowledgment of its value. It is not the consumer alone who benefits by the therm system, for in the industry itself the new interpretation of results is leading to increased efficiency. At first the computation of working results on a basis of therms per ton of coal carbonised rather than cu. ft. of gas of standard calorific value was somewhat resented, since it was felt that there was essentially no difference in the two methods of stating results. Fundamentally there is no difference, yet it is probable that the adoption of this system is likely to constitute a very great step in the appreciation of the coal conservation problem. Though there is no intrinsic difference, the gas manufacturer to-day sees more clearly that the ship, barge or wagon bringing coal to his works is delivering a load of therms, a certain proportion of which may be distilled off by heat, and that it is his duty to distribute these therms so carefully between gas, tar and coke, or coke, tar and gas, as the case may be, that the process may be carried out with the maximum conservation of thermal energy.

The author's experience in the working up of chemical by-products has brought him into the closest working relationship with the chemical industry, and he has observed that the chemical manufacturer approaches his task with a materially different outlook from that of the manufacturer of gas, who, in the past, has not universally realised that he is operating what is essentially a chemical process. In the chemical industry few reactions are carried out on the large scale to give the full theoretical yield of product, but a fierce struggle exists among chemical manufacturers to attain the highest possible yield, as their power to compete in the open market is largely determined by the efficiency of the process adopted. The amount of aniline made from unit weight of benzol, the amount of beta-naphthol from naphthalene or of anthraquinone from anthracene, is measured and controlled with the greatest diligence. The chemical industry can only flourish if these principles of conservation, necessitating a maximum yield of products together with complete utilisation of by-products, are studied and developed

day by day. The gas engineer to-day realises that his task differs from that of the chemical manufacturer only in the fact that he deals in therms and that his efficiency to compete depends upon his ability to market solid, liquid and gaseous therms in the most economical way. Each new development in the knowledge of the constitution of coal or of its behaviour under heat—whether it be derived from the University of Leeds, the Imperial College of Science, the Fuel Research Board or the gas industry itself—reveals the true chemical nature of the coal distillation process.

Obviously the major duty of the gas technologist is to manufacture gas, but this responsibility should not cause him to overlook the fact that it is always possible to distribute the therms of the original coal between gas, tar and coke in a variety of ways. The nature of the distribution is determined by the type of process adopted and by the conditions of its operation. During these lectures it is proposed to deal with these two aspects of the process of carbonisation. For the moment, it will be agreed that in the interests of the main product—coal gas—it is essential that the utmost attention should be devoted (as in the chemical industry) to all subsidiary products. When it is generally realised that these subsidiary products are sources of potential therms, they will be placed in a position only just second to that of gas, and the word "residual," will, it is to be hoped, entirely disappear from the industrial vocabulary and be replaced by the term "by-product."

In pursuing this interpretation of the carbonisation process as one in which the original thermal energy of the coal is distributed into more useful and economic forms, it is interesting to study the distribution effected on the one hand by high and on the other by low temperature carbonisation. Fig. 1 represents the general distribution of therms in each process, the coal being assumed to contain 300 therms per ton.

In the case of high temperature distillation (without the admission of steam), 1 ton of coal containing 300 therms will yield about 72 therms as gas of 560 B.Th.Us. per cu. ft. and some 17 therms as tar, leaving coke containing about 199 therms. The process loss will be of the order of about 12 therms. It will be observed that the loss in the case of low temperature carbonisation is of the order of 16 therms, as compared with 12

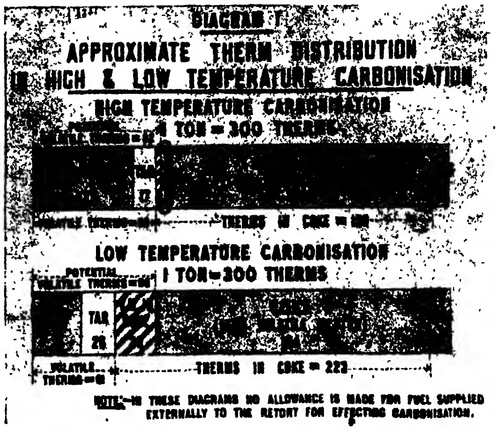

Fig. 1.

therms in high temperature carbonisation. The loss of therms from the original coal substance is due in both cases to the fact that the heat required for distillation is not taken wholly through the walls of the retort, but is partly supplied from the coal substance itself, principally during the early stages of its carbonisation. It is, therefore, not surprising to find that the loss experienced during the low temperature process, when exothermic reactions predominate, is greater than in complete carbonisation, where the loss due to the liberation of heat during the exothermic period is partly neutralised by the conversion of sensible heat into potential heat at the higher temperatures. The low temperature carbonisation of 1 ton of coal containing originally 300 therms yields some 35 therms as gas of 1090 B.Th.Us. per cu. ft. (3200 cu. ft.) together with 26 therms as low temperature tar, and 223 therms as coke still containing 9.3% of volatile matter. Determinations made upon low temperature fuel containing about 10% volatile matter have shown that the 9.3% of volatile matter remaining in the coke would represent about 29 therms per ton of the original coal. Now if this potential volatile matter be added to the amount actually obtained, there is practically no difference in the yield of so-called volatile therms and coke therms in the two methods of carbonisation. Such slight difference as does exist is to the advantage of high temperature carbonisation but this may be fortuitous. There is, of course, a difference in favour of low temperature carbonisation represented by the somewhat lower fuel consumption required for the process of distillation, but the by-products, gas and tar, and even the solid fuel

itself, must not be utilised for this purpose; the therm in its cheapest form should be employed, as is the case with coal gas manufacture.

From these results, which have been obtained from the same sample of coal, it would appear that the low temperature process is not superior from the point of view of efficiency of distribution. It simply results in a different distribution of the thermal energy of the original coal—it is the high temperature process arrested. This is a most important observation, in view of the fact that the pure chemist is naturally inclined to believe that high temperature carbonisation, involving as it does drastic decomposition of the coal substance, is a wasteful process, and that the low temperature treatment is more conducive to the conservation of the energy of the coal substance. It is known that drastic decomposition can and does take place, and this subject will be dealt with later. Provided, however, the high temperature process is conducted so as to obtain yields similar to those indicated in the diagram, there would appear to be no ground for supposing the low temperature process to be definitely superior from the point of view of conservation of energy.

The 29 therms of potential volatile matter retained in the low temperature coke are subsequently burned in the household fire as a low calorific value gas, for there are no complex hydrocarbons to be distilled away or partially burned with the production of soot or smoky flames, as is the case with ordinary household coal; the material is, in fact, a coal-gas coke mixture. There is no wonder, therefore, that agreeable results are obtained, but the question is whether the consumer of this fuel can afford to pay for the potential coal gas left in it. Apart from the technical difficulties involved, the problem of low temperature carbonisation is largely one of economics. Coal is conveyed to, and lifted into, the retort, heated to a temperature of some 600° C., 61 therms of volatile matter per ton distilled away, and the material remaining subsequently cooled and discharged. If this process were carried out at a higher temperature, and for a slightly longer period, thus entailing no appreciable increase in labour costs, the volatile matter would be converted to gaseous therms and sold at the ruling price of gas per therm. There is not likely to be an appreciable difference between the value of the therm in high and in low temperature gas and, unless the tar produced in the low temperature process commands a higher value on the thermal basis than high temperature tar, it would appear that the consumer of low temperature fuel must be prepared to pay for practically the whole of the potential volatile therms at their true gas price before the process of low temperature distillation can be expected to be as remunerative as that of high temperature.

This somewhat lengthy analysis of the low temperature process has been introduced partly for the purpose of demonstrating the fact that the destructive distillation process should be viewed as a means of converting the energy of the original coal into therms of different value distributed between the various products, partly with the object of proving the value of the therm interpretation of carbonisation results and finally to prepare the way for demonstrating that the manner of distribution of the volatile therms—whether as gas, tar or as part of the solid fuel—is controllable and may be altered or adjusted by the method of distillation adopted.

It is now proposed to deal with the loss of gaseous therms which frequently takes place in carbonisation practice. The secret of preventing wastage of gaseous therms and of conserving the energy of the original coal lies in the possession of a suitable design of retort bench fittings and accessory plant, and in the maintenance of these in the highest possible state of efficiency and repair. This cannot be over-emphasised, for in the gas industry there are many investigators striving to devise processes which shall represent a superior degree of coal conservation during the distillation process, whereas the author believes that what can be done in this respect is small compared with the economic advantages to be gained by increasing the efficiency of working results from existing installations.

In the design of retort settings the engineer and chemist agree that the following requirements are essential:—

(1) That the distribution of heat throughout the length of each retort should be fairly uniform.

(2) That the temperature should decrease sharply at the ends of the retort.

(3) That the rate of transmission of heat

through the wall of the retort should be practically the same in the case of all retorts in one setting.

(4) That the retort should be of such dimensions that complete carbonisation of the coal charge is possible, and whatever be the mass of charge decided upon, it is naturally of great consequence that it should lie evenly throughout the retort. This latter factor is, of course, dependent upon well-designed and well-operated charging machinery.

This list of requirements could, as is well-known, be materially expanded. A technical chemist accustomed to making chemical and physical determinations in the retort-house possesses concrete ideas of the fundamental requirements in the design and working of furnaces and retort settings, and is appreciative of their influence upon the final carbonising results. He is thus able to indicate sources of loss, and the conditions which produce unsatisfactory process yields, but his ability to design or re-design large scale retort settings and plant, in order to attain the required end, is limited. So far as the author's experience goes, the desired adjustments are better left conjointly in the hands of the technical chemist and of the observant gas engineer, the latter, by a process of trial and error in the design of retort settings, having become master of the subject.

The question of the effect upon thermal yield and upon the constitution of the gas, of maintaining in a state of good repair the retort and its external fittings, is one to which considerable attention has been given by the author. Carbonising trials have been carried through both in sound and in leaky retorts, and the effect of different types of leaks upon the volume, calorific value and composition of the gas produced has been examined. These trials have been conducted in an experimental plant in which it was possible to carbonise 3 tons of coal per day. A typical Durham gas coal has been used throughout, and the conditions maintained have been such as to reproduce results normally obtained by carbonising 10 cwt. charges in 20 ft. retorts for a period of 10 hours, with a combustion chamber temperature of 1320°C. The vacuum maintained during the period of carbonisation was 3/10″ water pressure, obtained by the maintenance in the hydraulic main of 13/10″ vacuum and 1″ liquor seal.

It will first be necessary to examine some typical carbonising results obtained, under these conditions, in tight retorts, and fig. 2 shows an average result obtained under the stated conditions. The gaseous thermal yield is of the order of 73.5 therms per ton, the total volume of 566 B.Th.Us. gas produced being 13,000 cu. ft. The first curve shows the volume of gas produced hourly and the second curve the gradual decrease in the calorific value of the gas during the period of carbonisation. One is at once impressed by the small amount of useful work effected in the last few hours when the rate of heat transmission through the walls of the retorts has been considerably reduced, and an examination of the analysis diagram, which

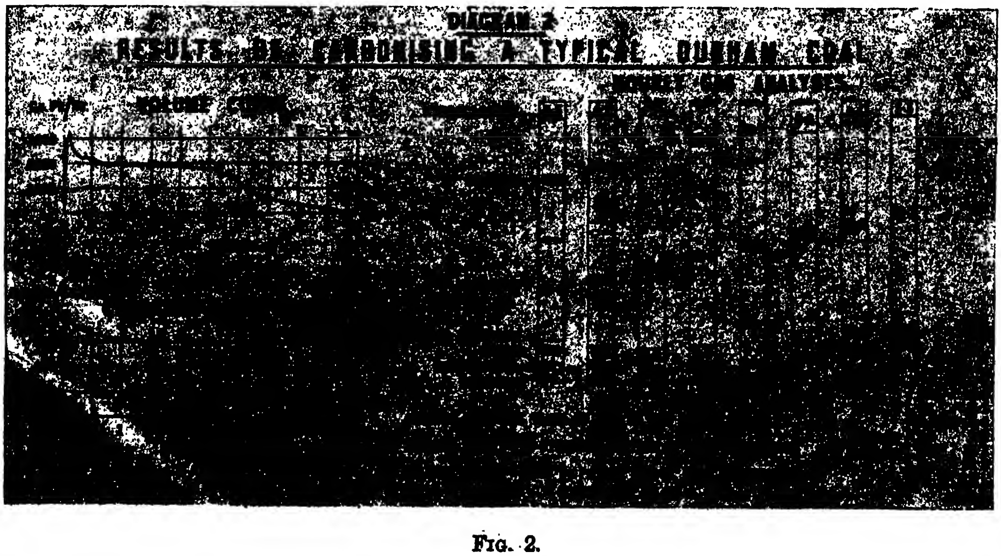

Fig. 2.

indicates according to the known method of presentation, the hourly changes in the constitution of the gas, confirms this impression.

The author has found that a convenient method of examining the amount of useful work effected during each hour of the carbonising period is to produce a thermal produced per hour and the breadth C the calorific value. The value of this means of representation is, in the first place, that the mass of the model itself is proportional to the thermal yield of gas from the coal, and, secondly, that a section taken at any one period shows in its area the amount of work being done at that instant. Fig. 4 shows

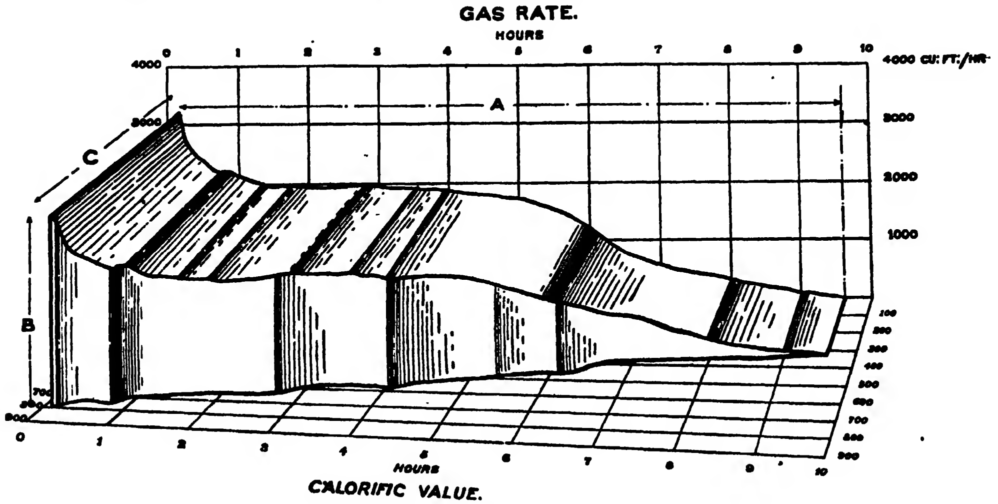

Fig. 3.

model. This is constructed by combining the hourly volume and calorific value curves of fig. 2. In fig. 3 it will be seen that the length A of the thermal model represents the time of carbonisation in hours, while the height B represents the volume of gas

SECTIONS SHOWING THERMAL YIELD DURING MIDDLE 10 MINUTES OF FIRST AND LAST HOUR OF CARBONISING PERIOD.

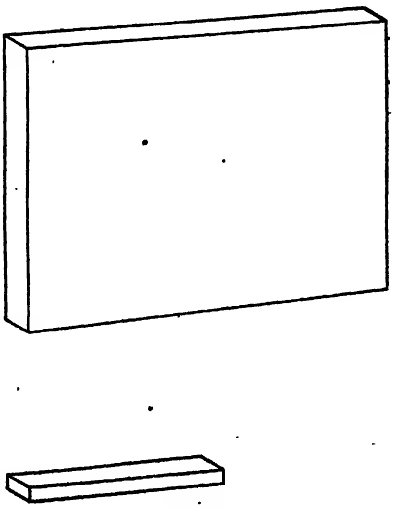

Fig. 4.

sections of the model taken from the middle 10 minutes of the first and last hours of the carbonising period, and the immense difference that exists in the amounts of useful work done in each case will be noted.

The thermal model shown in fig. 3 is constructed from a series of carbonising trials on an experimental plant, but the results are comparable with those which may be obtained in average practice. As indicated before, one of the outstanding observations to be made is the large volume of gas of very high calorific value evolved in the first ten minutes after closing the door of the retort. In this period 5.04% of the total gaseous therms is produced, and knowing that the constituents of such a gas are unlikely to be sufficiently stable to withstand contact with the heated sides of the retorts, it was decided to attempt to apply a much higher vacuum during this early stage of the carbonising period for the purpose of preventing decomposition. Carbonising trials were carried through in which there was an initial vacuum of 20/10″, which was reduced by 3/10″ every 10 minutes, until the normal vacuum of 3/10″ was attained. There was thus a gradually decreasing vacuum — higher than the normal — operating during the first hour

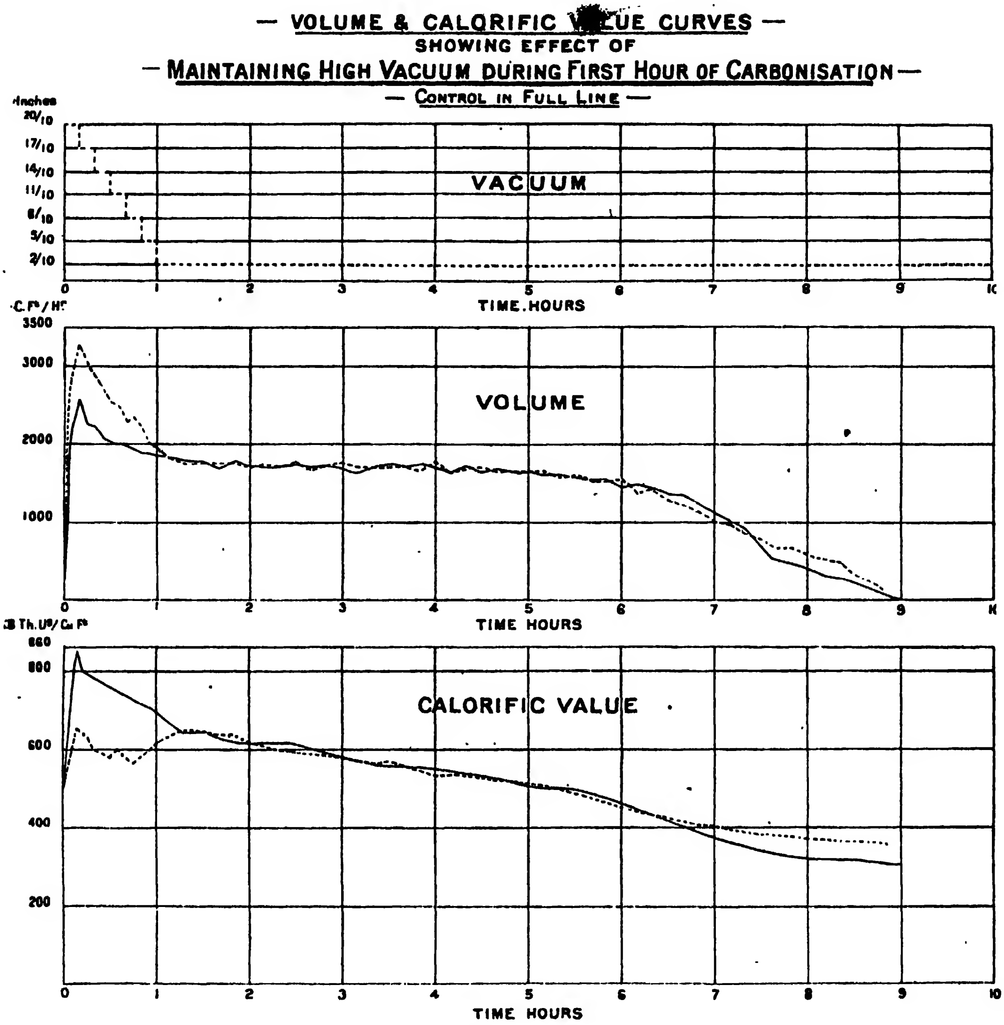

FIG. 5.

of carbonisation, while the normal vacuum was maintained throughout the remaining carbonising period. These conditions proved successful in materially reducing the calorific value and extending the volume of gas made during the early stages of carbonisation (fig. 5). The full line curve represents the control experiment carried out under normal conditions, in which case the average calorific value of the gas was 563 B.Th.Us. and the yield 73.5 therms per ton of coal. A comparison of the resulting thermal model with that obtained under standard conditions also emphasises the effect of the new conditions upon the calorific value and volume of the gas produced (fig. 6). In the carbonisation trial, under these special conditions, the average calorific value of the gas was 542 B.Th.Us. and it is disappointing to observe that there was no apparent improvement in the gaseous thermal yield. It would appear from this and a number of similar experiments, that, provided the retort is tight and in good condition, little advantage is likely to materialise from the adoption of a procedure of this nature. Had there existed a hole or cracks in the retort, this method of working would be expected to prevent losses from the retort when the rate of evolution of gas is at its highest. The procedure is, however, only of academic interest, for it is not generally possible in gas-works practice to produce a high pull only in those retorts which have been newly charged.

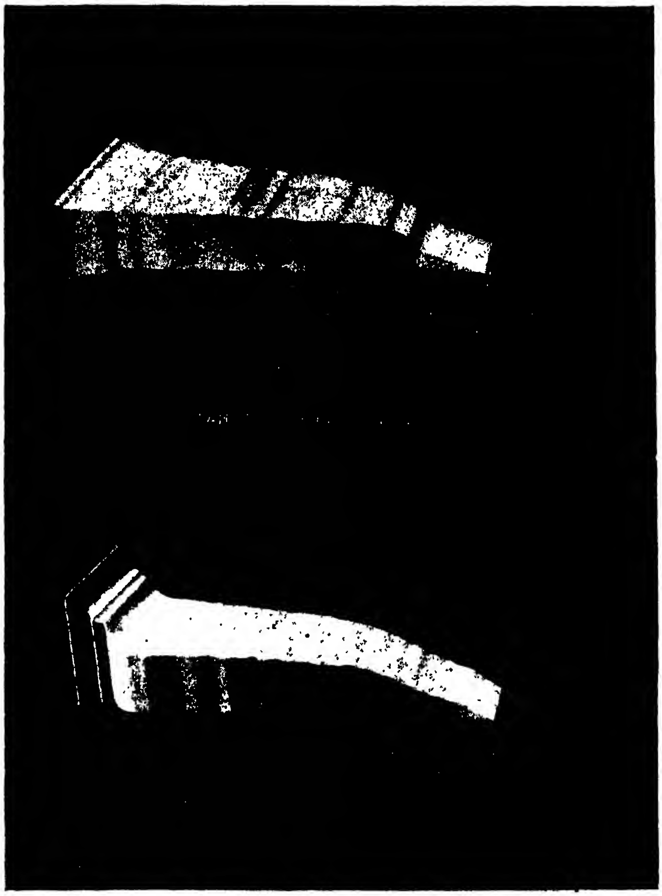

Fig. 6.

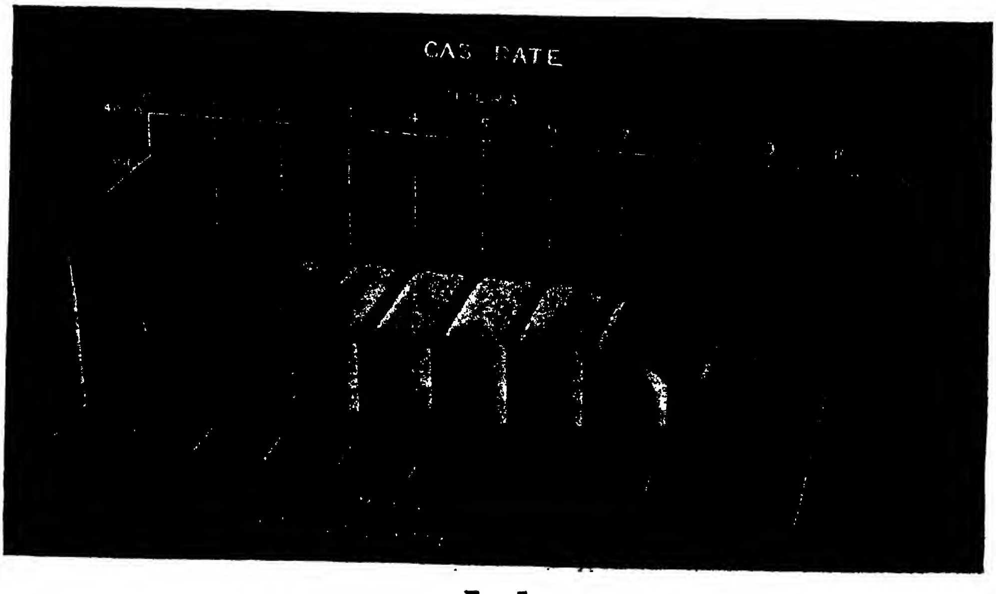

Fig. 7.

The thermal models constitute an excellent device for detecting any slight differences in the carbonising process, or for determining the effect of any adjustments of the conditions of working. The model shown in fig. 7 furnishes an example of the sensitivity of these models. It demonstrates results obtained from normal carbonising procedure. For obtaining a high thermal yield it has been found necessary to reduce the vacuum in the hydraulic main of any one section to level gauge when some of the retort doors of that section are open for charging or discharging. As hourly charging is adopted, it is thus the practice to reduce to level gauge for 10 minutes during each hour. An examination of the thermal model will show that at these periods there is a definite indent in the volume curve, and that immediately following this, when the vacuum is re-established, there is a corresponding peak in the calorific value curve. It is evident, therefore, that gas has been accumulating in the retort during this period of level gauge. Generally speaking, provided the retorts are tight, this method of procedure does not materially affect the thermal yield of gas. It will be demonstrated later how disastrous is this practice in the case of an unsound retort.

In order to show clearly the composition and thermal value of the gases obtained by carbonisation under normal conditions, it is possible to construct from the time/volume curves an analysis model for the various gaseous constituents. The lower portion of fig. 8 shows the structure of such a model, which is composed of various sections representing the different constituents of the gas, the height of each section representing the calorific value of the constituent, and the breadth of the section the volume of that constituent produced at any one moment during the whole period of carbonisation. Thus, at any given time during the carbonisation process, it is possible by reference to the appropriate section of the model to observe exactly to what extent any constituent is contributing to either the volume or the calorific value of the gas being evolved. It is evident that, by looking down on the model in plan, a simple reproduction of the

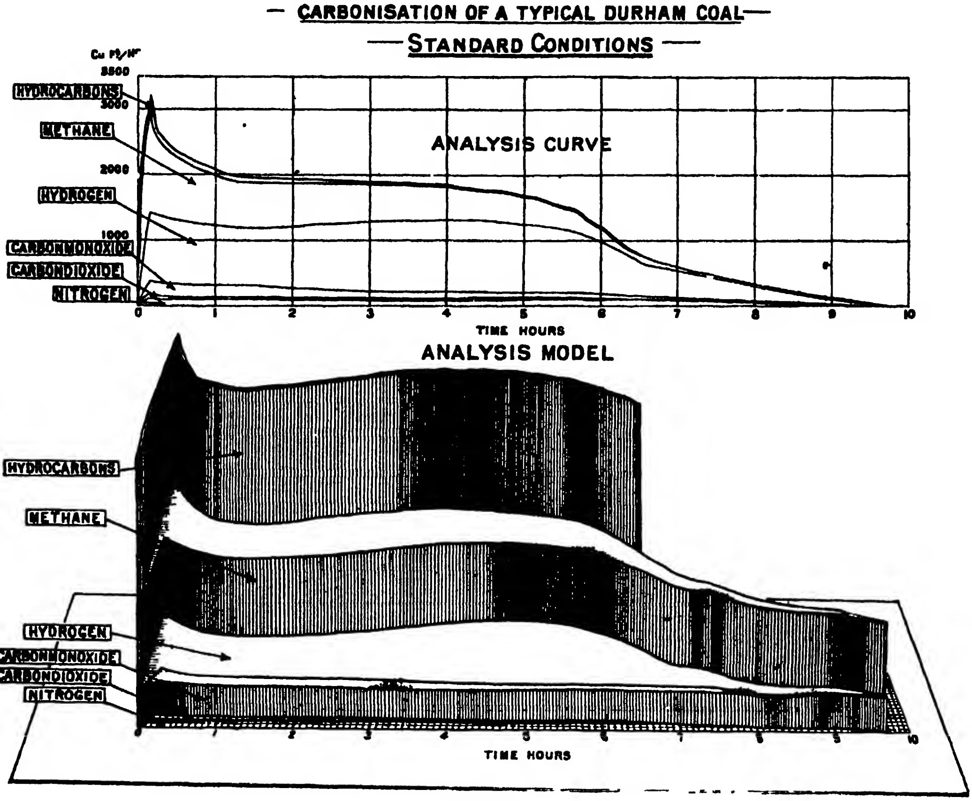

FIG. 8.

stratified analysis curve will be seen, and the analysis model is produced by making the height of each constituent proportional to its calorific value.

From this analysis curve it will be seen that the production of inert constituents is fairly constant up to the seventh hour; carbon monoxide is evolved fairly evenly until the eighth hour, when it gradually becomes less in quantity, while hydrogen gradually increases during the carbonising period until a maximum is attained in the region of the fourth hour. Methane production is at its height during the first ten minutes and falls off sharply until, at the end of the second hour, a fairly constant quantity is being produced. The unsaturated hydrocarbons, important though they are as regards their contribution to calorific value, are quite small in volume and tail off at the sixth hour. Whereas the analysis curve shows the hourly production of each constituent of the gas, the analysis model demonstrates the contribution of each constituent to the total thermal yield and also to the effective work, at any one moment during the whole carbonising period. It thus shows in a convincing manner the true value of each constituent. In the case of the inert constituents, nitrogen, carbon-dioxide, and oxygen, it is obvious that as these possess no calorific value they will be represented without height in the model, and it will be seen that they are shown at the foot of the model possessing area only. The most outstanding feature of this model is the layer representing the unsaturated hydrocarbons which disappears at the end of the sixth hour. This layer has considerable height owing to the high calorific value of the unsaturated compounds, but is practically a knife edge owing to their small volume.

Reverting now to the soundness of the

— VOLUME & CALORIFIC VALUE CURVES —

SHOWING EFFECT OF

— HOLE IN RETORT —

— CONTROL IN FULL LINE —

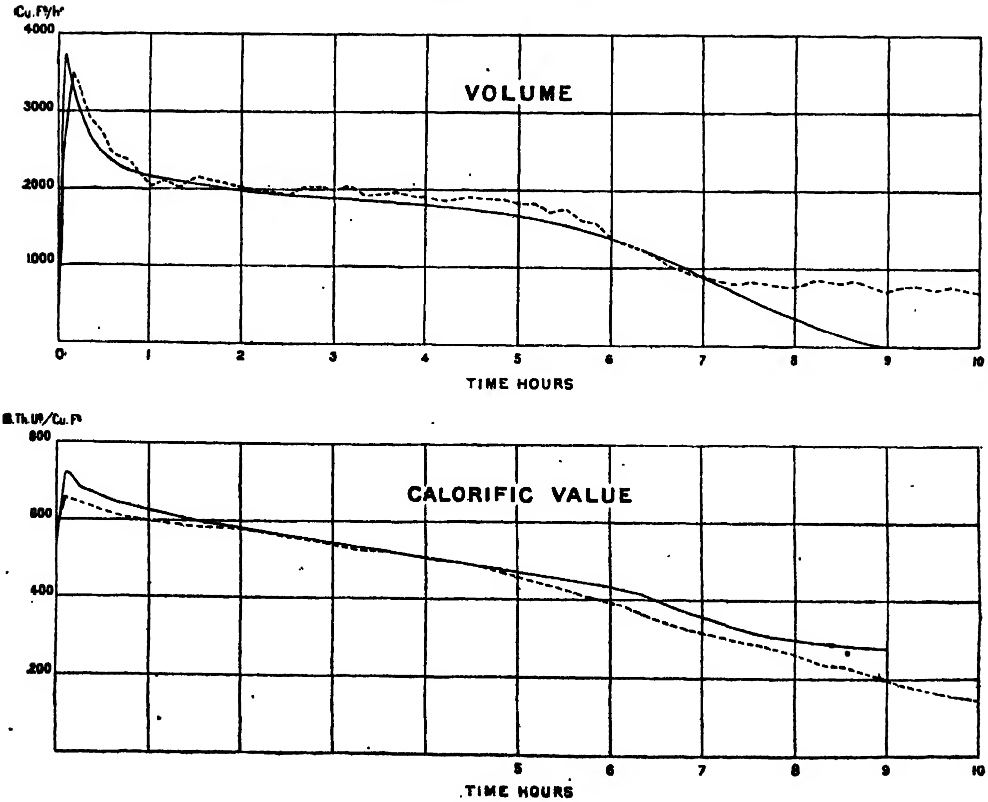

FIG. 9.

retort and its effect upon the nature of the gas made and the yield of gaseous therms, fig. 9 represents the results obtained from working under standard conditions—*i.e.*, with a continuous pull of 3/10″—but with a hole of ½″ diameter in the top of the retort at a point equivalent in position to the centre of a 20ft. retort. The broken curves show, in comparison with the control curves, the changes in volume and calorific value resulting from the hole in the retort. It will be seen that, whereas the volume peak is reduced at the commencement of carbonisation, due to the loss of the rich gases through the hole in the retort, the B.Th.Us. as against 532 B.Th.Us. in the control experiment. The most interesting observation to be made, however, is that the manufacture of gas does not stop at the tenth hour, for at this period there is being produced about 700 cu. ft. per hour of a gas of 180 B.Th.Us. per cu. ft. This gas is producer gas, as will be seen from an examination of the analysis curve and analysis model (fig. 10). A comparison of these curves with those obtained from a normal carbonisation demonstrates most clearly the actual differences in yields of the various constituents of the gas. The most interesting section of the analysis curve is that relating

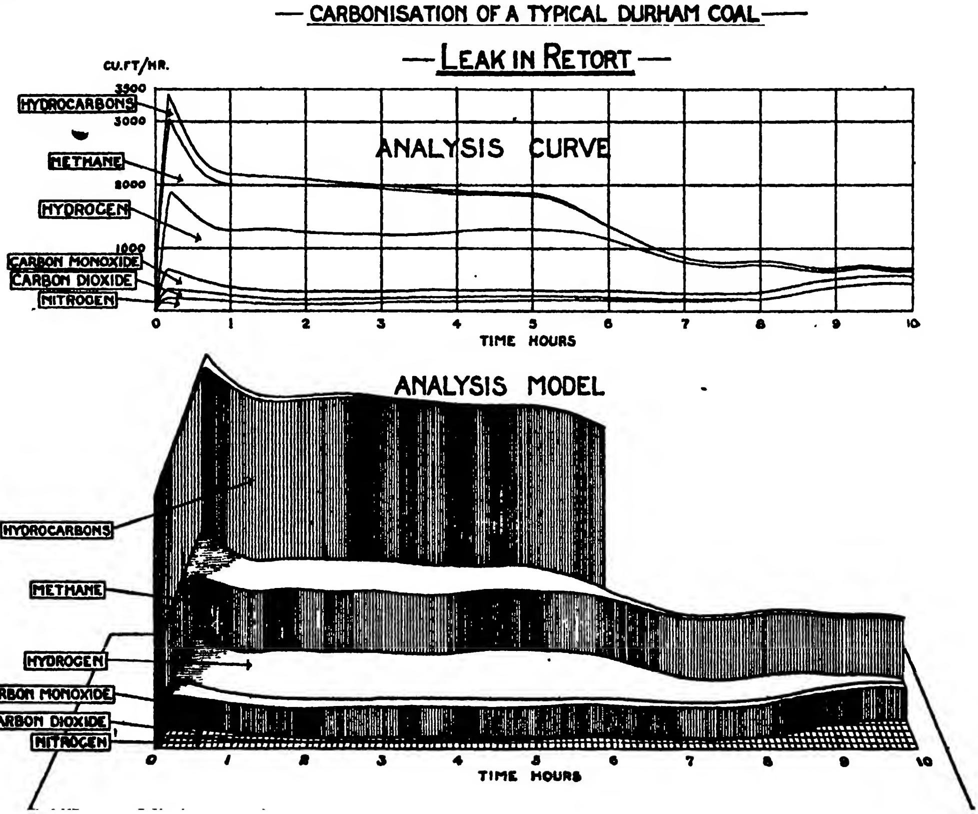

FIG. 10.

volume is increased throughout practically the whole of the remaining period of carbonisation. This increase is probably due to the entry of furnace gases, which will not only add to the volume but may also lead to more rapid carbonisation taking place as the result of their scouring action. On the other hand, the calorific value of the gas is lower throughout the whole period of carbonisation, the calorific value of the final gas being 482 to the last few hours of carbonisation, where the effect of the producer gas reaction is clearly shown. The large increase in the nitrogen content of the gas passing over in the final stages is to be expected, but it is surprising that the time of contact in the retort is sufficient to convert the carbon-dioxide of the waste gases to carbon monoxide, at the expense of the coke.

The thermal yield of gas will be dependent

upon the time the charge is allowed to remain in the retort and in the above test it amounted to about 75 therms per ton. It is a very difficult matter to determine what is the precise thermal yield of true coal gas under these conditions of carbonisation, for it would be required to know at what stage of the process the producer gas reaction commenced. Rough calculations from the analyses show, however, that 1 to 2 therms of true coal gas have been replaced by producer gas therms. By continuing the carbonisation process and increasing the quantity of producer gas formed it is possible to obtain results apparently superior to those obtained in normal practice with tight retorts. If, however, it be desired to admix producer gas with coal gas for the purpose of dilution, it would be a far more economical process to manufacture the producer gas in the producer itself, and to add it under control (of course, preferably through the charge itself), rather than to cause the reaction to take place as the result of the indiscriminate admission of waste gas through holes or cracks in the retort; the heat required for the reaction has to be supplied through 3" of fire-clay and the manufacture of producer gas from waste gases in a gas retort under these conditions is a costly process. It will thus be seen that by manufacturing coal gas in a pierced retort it is possible to obtain an excellent thermal yield of gas and, in addition, a volume yield which might be very useful to manufacturers who continue to sell on a volume basis.

Before leaving the subject of the effect of a ½" hole in the retort upon carbonising results, it should be noted how different must be the results obtained from retorts in which there exists a larger or smaller hole than that selected above, or where the holes are at points different from that in the foregoing example. It stands to reason, for example, that a hole in the retort in close proximity to the ascension pipe would not give conditions conducive to the producer gas reaction. There is but one conclusion to be arrived at, and that is that in the interests of high gaseous thermal yields all retorts should be

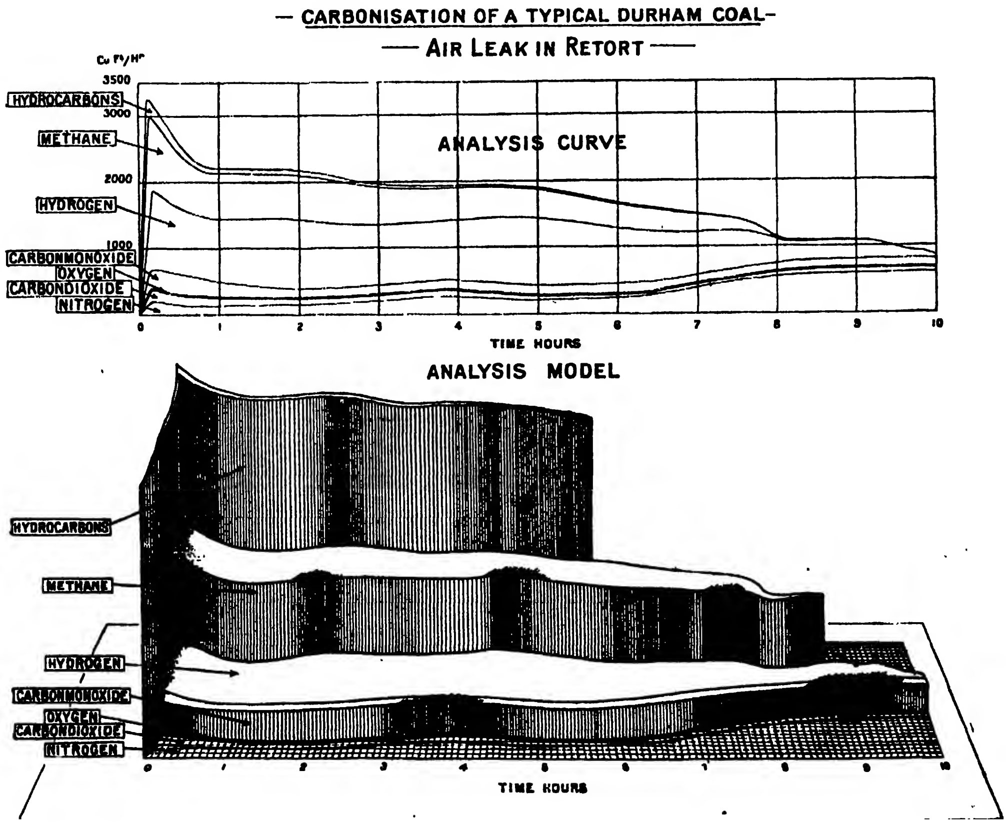

FIG. 11.

maintained in a high state of repair. If it is desired to admix water gas or producer gas, it is certain that this is best done by its admission through the charge as it is undergoing carbonisation, or failing this, by subsequent admixture, but it should always be done under perfect control by means of a regulating valve.

However great may be the disadvantage of drawing into the retort waste gases from the retort setting, the admission of air to the gas before it has cooled below the ignition point of all of its constituents is more than ever to be avoided. Before, however, passing to a consideration of the results of admitting a small quantity of air to the gas before it passes into the ascension pipe, it may be of some interest—perhaps mainly academic—to note the effect of allowing a small current of air, as distinct from waste gases, to enter into what would practically be the centre of a 20 ft. retort. The air introduced eventually does considerable damage, as may be seen from an examination of the analysis curves and model (fig. 11). The destruction of the hydrocarbons by the introduction of oxygen is indicated by the high carbon dioxide content of the gas throughout the whole period of carbonisation, while the producer gas reaction appears to proceed in much the same way as in the pierced retort. The total yield of hydrogen is smaller than in the case of the introduction of waste gases, while the high nitrogen content of the gas passing over towards the completion of the carbonisation is again an outstanding feature of the curve. The final result of the procedure is to manufacture 17,300 cu. ft. per ton of coal carbonised, the calorific value of the gas being 419 B.Th.Us. per cu. ft., and the thermal yield about 70 therms per ton.

A yield of 70 therms per ton is far from a poor one, but if this coal were carbonised in

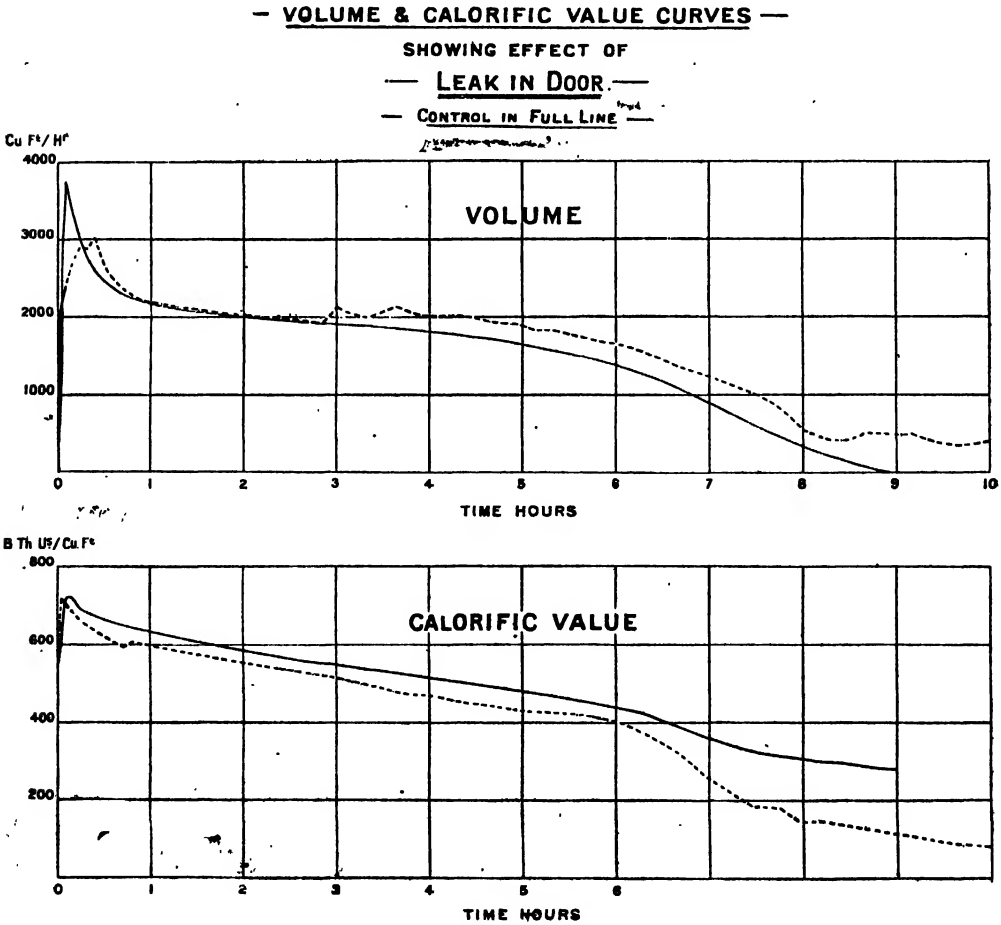

Fig. 12.

a tight retort, and there were added such a proportion of producer gas as was made during the carbonisation process in this example, the final result would probably be at least 75 therms per ton. It may be imagined that what has actually happened is that about 5 therms per ton of coal have been destroyed in the retort, reducing what would have been a 73 therm yield to 68, but that some 2 therms of producer gas have been added at the expense of the burnt out products in the retort. The real conclusion to be drawn from an experiment of this nature is that the gaseous thermal yield per ton of coal carbonised is, when taken by itself, no indication whatever of the efficiency of the process or of the degree to which conservation of thermal energy has been practised.

In order to determine the effect of admitting a small quantity of air into the gas before it passes into the ascension pipe, one door in a through retort was wedged with a 1/32" distance piece, whereby a mean slit of 1/64" was produced over the whole door oint. A totally new set of conditions is experienced by allowing a small quantity of air to be introduced at this point. The volume curve (fig. 12) again shows that a quantity of rich gas is lost in the initial stages of carbonisation, while the volume of gas obtained during the last few hours is considerably increased. The calorific value of the gas is also appreciably lower than that obtained under normal conditions. The analysis curves and model (fig. 13) show that there must have occurred a very different set of reactions from those in the foregoing examples of leakages, and the variation in results is attributable to a multitude of reactions which are taking place in the ascension pipe. The two outstanding points to be observed in the analysis model are that the hydrogen yield has appreciably decreased, particularly towards the end of the process, due probably to its conversion into water vapour by combustion in the ascension pipe, while the oxygen content of the final gas is practically the same as in gas obtained from a tight retort. The disappearance of oxygen is an indication that combustion must have taken place to an

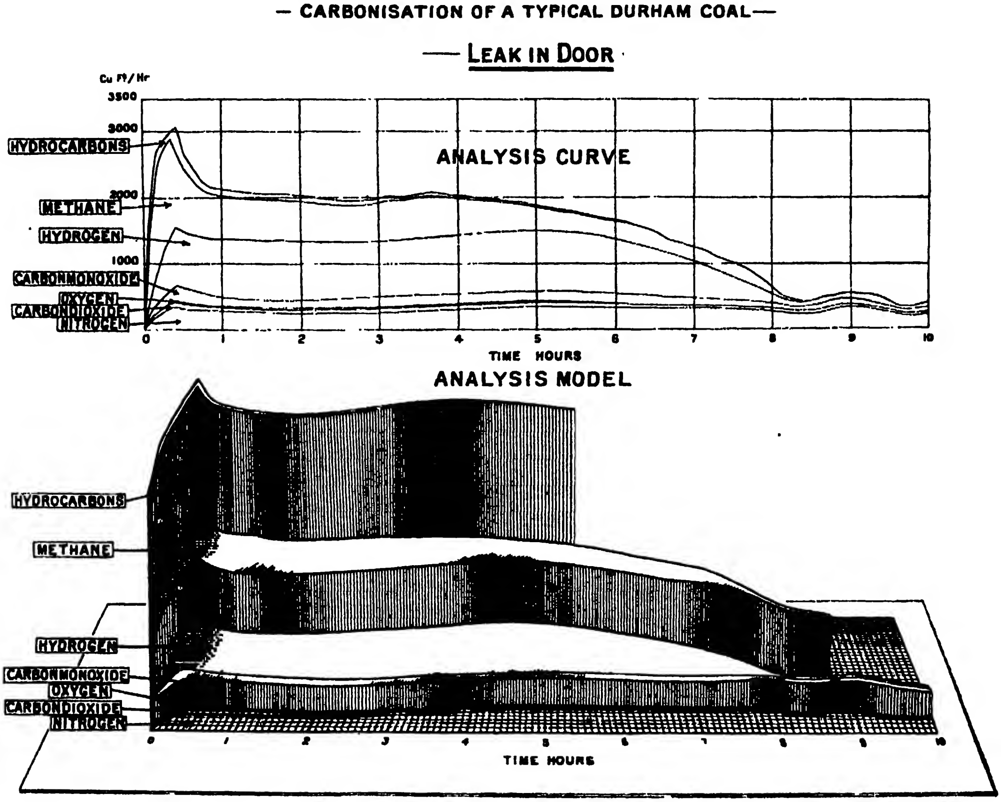

Fig. 13.

appreciable extent. It is undoubtedly true that air drawn in at the retort mouthpiece is capable of producing the combustion of gas and tar in the ascension pipe. By this means, higher temperatures are attained in the ascension pipe itself, which is, in consequence, converted into a tar-still, and it is beyond the wit of man to unravel the nature of the reactions liable to be taking place therein. The author suggests that one of the main causes of stopped pipes is the introduction of oxygen, and the conversion of the ascension pipe into a tar-still for the manufacture of pitch.

With the introduction of air into the gas during its passage into the ascension pipe there is again an increased volume of gas produced—15,550 cu. ft. per ton—and once again the therm yield is far from poor—viz., of the order of 70 therms per ton. In this case the destructive effect of combustion in the ascension pipe has been partly replaced by the distillation and cracking of tar. Once again it is impossible to determine the loss of true gas therms by this process of combustion in the ascension pipe. That there has been a considerable loss is evident from the curves and models. The outstanding disadvantages which accompany this method of procedure are the disastrous effect upon which is liable to cause combustion of valuable gases in the ascension pipe, with the production of technical difficulties in the form of stopped pipes,

It has been demonstrated that destruction of gaseous therms takes place with a pierced or porous retort or badly fitting door, or, in fact, any unsound fitting on the vacuum side of the retort-house governor, which allows air to be admitted before the gas has cooled down to the temperature of the ignition point of its own easily combustible constituents. Yet, on the other hand, it has been seen that the therm yields of gas under these conditions are not altogether unsatisfactory. It has been shown, however, that the gaseous therm yield, when taken alone, does not represent the efficiency of the process or the degree of conservation practised. This is due to the fact that, whereas the introduction of furnace gases through the coal charge has a beneficial effect on the therm yield, there is always the possibility that the richer gases, produced in the earlier stages of carbonisation, may escape through the holes by which the scouring inert gases enter. It is evident, therefore, that the highest thermal yield in the form of gas is to be obtained by carbonising in the soundest possible retort. Now it is impossible to imagine that even in

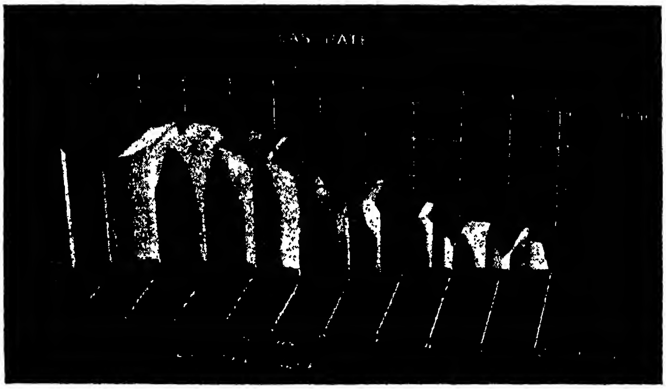

FIG. 14.

the quality of tar produced and the additional retort-house cost incurred by reason of stopped pipes. It follows that these disabilities must occur to a similar degree with a retort door or fitting possessing a slight leak, and the little puff of smoke which may be seen issuing from the retort mouthpiece during the first few hours of the carbonising period does not represent the total loss that may be incurred, for with the disappearance of the smoke there will be drawn in air, the very best conducted works all retorts are maintained in a state of first-class repair. Since it has to be assumed from present knowledge of fire-clay materials that retorts must be expected to develop cracks or holes, the best means of obtaining the highest thermal yields from a setting in a bad state of repair will be to operate each retort according to its condition. This will necessitate varying the vacuum maintained during carbonisation to a different degree

in each retort, and the possession of a device to effect this would carry with it many other advantages which need not be analysed at the moment.

Fig. 14 shows how disastrous may be the result, in the case of a pierced retort, of the practice of reducing the vacuum to level gauge when the retort doors of a section are open for discharging and charging. The thermal model, the analyses curves, and analysis model (fig. 15) need little comment. fied by the different heights assumed by all these models. It has been found that the volume of gas produced is determined by the temperature that the retort itself has attained during the interval between discharging and recharging. The temperature of the walls of the retort mounts rapidly after the withdrawal of the charge, due partly to the increased rate of heat transmission which occurs and to the fact that retort carbon is burned by the air entering through the open

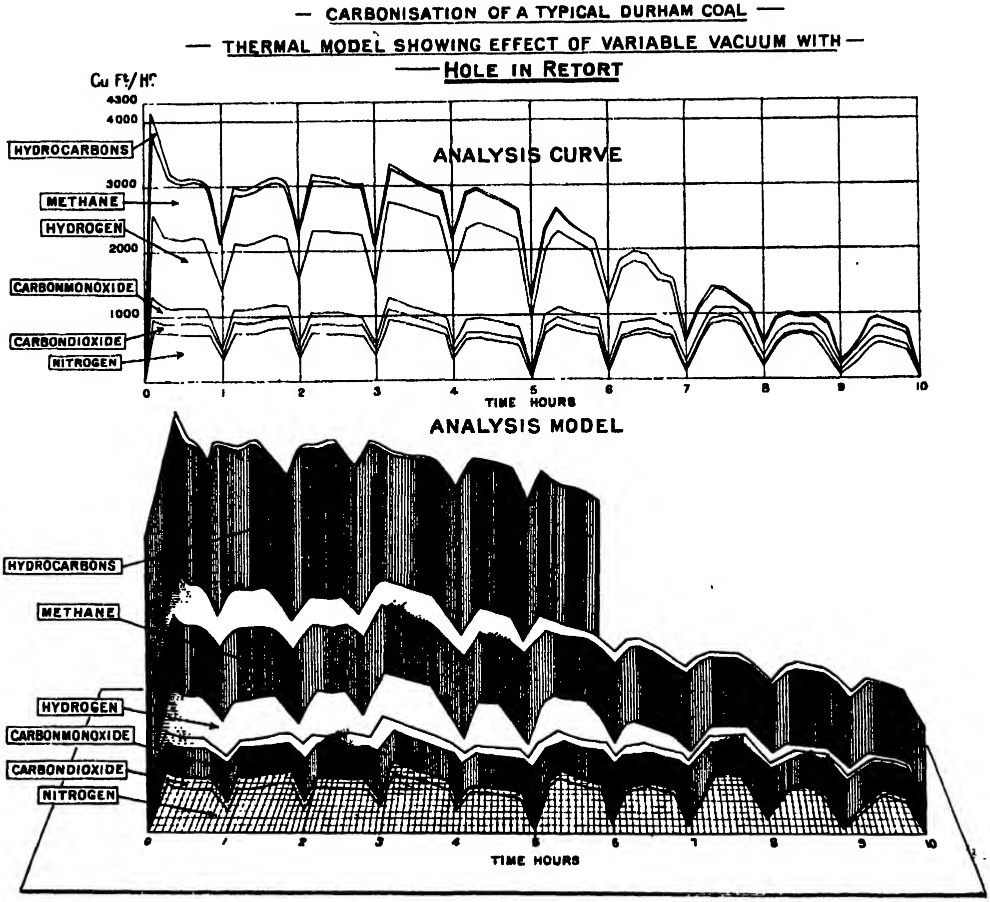

FIG. 15.

At each period of releasing the vacuum a large loss in volume is realised and the curves become almost mountainous. The thermal yield of gas was as high as 74.6 and the calorific value of the gas below 400 B.Th.Us. per cu. ft.

One point to be noted with regard to the thermal models relates to the varying volume of gas made immediately subsequent to closing the retort door, as exempli- door. Apart from many other reasons why it is advantageous to close the door as rapidly as possible after recharging the retort, this is given as one which is not usually appreciated.

Finally, it is interesting to attempt to realise how uncontrollable becomes the carbonisation process by allowing the retort-house to fall into disrepair, or by attempting to utilise unsuitable plant and machinery.

The retorts, some of which may be scurfed, while others require scurfing, will present different degrees of porosity, and either loss of gas or the producer gas reaction will take place, according to the length of time the charge has remained in the retort, and the position of the hole in the retort. Many retorts are controlled by one governor, and the conditions under which the retorts are operated must be the same, though retorts in bad condition require to be operated differently from those in good condition. An unequal distribution of heating gas in the setting not only causes certain retorts to be maintained at appreciably different temperatures, but produces in any one retort an unequal heating effect. By no system of control can individual retorts be operated according to their condition, or age, or to the evenness and degree of their heating, or the lie of the retort charge, or the tightness of the retort door, and yet the influence of these factors, not only on the nature of the gas made, but upon the thermal yield of true coal gas, is very appreciable.

As a chemist, the author is not displeased to find chemists well established in the retort-house, and in a well-designed and conducted house they can save large sums of money. They are incapable, however, of serving any useful purpose in a retort-house which manages itself by virtue of its uncontrollable conditions. This picture is perhaps drawn a little forcibly, but it is substantially true, and the retort-house chemist or foreman, or whoever may be responsible for efficiency, obtains the best result circumstances allow. With carbonising conditions only partly under control, the process becomes an art, or a knack, or an acquired additional sense, and the author has seen some fine old artists in the form of retort-house foremen work miracles in the management of "unmanageable" retort-houses. Wonderful pottery was fired by the ancients, fabrics were dyed in a beautiful way by natives with vegetable dyes applied in the crudest manner, and an observant cook may prepare an excellent dinner with half the burners of a gas cooker stopped up with fat and grease, but all these methods are costly and the percentage of failures is high. The carbonisation of coal becomes a science only when the reactions taking place are carefully controlled by the chemist, so as to obtain the most efficient results, and this is possible only when the engineer installs a first-rate retort-house and maintains it in a first-class condition.

NOTES ON BOOKS.

COLOUR SCHEMES FOR THE HOME AND MODEL INTERIORS. By Henry W. Frohne and Alice F. and Bettina Jackson. London: J. B Lippincott Company. 25s. net.

There are some fortunate individuals so gifted with an eye for colour that they cannot make a mistake when they set about decorating a room. These, however, are the rare exceptions. Most of us, when we set about the task of home-making, find that, in spite of the best intentions, we have made bad mistakes and condemned ourselves either to live with what displeases us or to incur further expenditure in correcting our errors. For such as these the volume before us will prove a godsend. The authors have stated broadly the more fundamental principles of good design and colour harmony, and while wisely abstaining from any academic exposition of these principles, they have given the lay reader sufficient guidance to enable him to produce a comfortable and harmonious home.

The book is written by Americans and naturally deals largely with American conditions, but that only affects to a very small extent its value for non-American readers. Clever hints are given as to the best ways of treating rooms of ugly or awkward shapes, the choice and disposition of curtains, floor coverings, and the principles which should guide one in selecting furniture. Specimens of rooms furnished according to the authors' taste are shown in a number of excellent photographs, and a word of praise must be added for the very charming and delicately coloured plates giving suggestions for the decoration schemes of various rooms.

RHUBARB IN SZECHWAN.

Rhubarb plants are found throughout the highlands of the Chinese-Tibetan border, but, as in the days of Marco Polo, the best is obtained from the regions of Tangut, which stretch from Sungpan, Szechwan province, to the south-eastern corner of Kansu province. Rhubarb grows among scrub and rocky watercourses at 7,500 ft. to 18,500 ft. altitude. It is, however, also cultivated, but the wild rhubarb is esteemed the best drug. The finest rhubarb, according to the *Chinese Economic Bulletin*, is secured from the species of plant known botanically as *Rheum plamatum, var, tanguticum*, and this is the variety most commonly met with in the extreme northwest of China and the contiguous Tibetan regions. From Tachienlu, a second grade rhubarb is exported in considerable quantities, mainly derived from *Rheum officinale*, although the variety *tanguticum* also occurs sparingly in that neighbourhood. Other species grow in the West, and are used as adulterants. In north-western Hupeh, *Rheum officinale* occurs in the forests, and is also cultivated by the peasants, but the quality of the drug is very poor. The Tangut regions enjoy a dry sunny climate,

and here the preparation is a much easier task than in the other districts mentioned. The change of climate probably affects the quality.

Unsightly pieces of rhubarb are occasionally rendered more attractive in appearance by turmeric; the same is true of powdered rhubarb. In testing the quality of the drug, about five grains of rhubarb are placed on white blotting paper with a few drops of chloroform. When the paper surrounding the powder produces a deep yellow stain similar to turmeric, a pinch of powdered borax is added, also a single drop of hydrochloric acid. If the stain is produced by the rhubarb, its colour will not be affected, but if the rhubarb contains turmeric, the colour will change to a distinct red in a few seconds.

The exact production in Szechwan province is unknown, but it is usually estimated at 10,000 to 15,000 piculs a year.

FORESTS AND FORESTRY IN ONTARIO.

In the course of a paper read before the British Association for the Advancement of Science at Toronto, Mr. E. J. Zavitz stated that of Ontario's total land area of approximately 407,262 square miles, 240,000 square miles might be classed as forest land. With a forest region so vast in area and running low in acreage yield, Ontario was confronted with a difficult problem in forest protection and administration.

About one-third of the acreage of this forest was of merchantable character, the remaining being either inaccessible or composed of areas of young growth.

Ontario was in a favourable position from the standpoint of the future development of forest policy, as the greater part of the forest area remained in the Crown, the timber-cutting rights only being leased. Of the forest area, approximately 23,000 square miles was dedicated and set aside as parks and forest reserves, although no real forest management had as yet been introduced.

Ontario's forests provided annual revenue to the State of approximately $3,000,000. The annual value of Ontario's forest products at the place of production totalled something over $100,000,000, with an investment in mills and equipment amounting to over $200,000,000.

WATER-POWERS OF CANADA.*

Canada is particularly fortunate in the nature, extent, and location of her power-producing resources. The water-power resources of Canada are widely distributed and of great extent. They are to be found in every province, and are most abundant in the central provinces, where the absence of native coal makes them of special value. Climate and topography are both favourable to the presence of water-powers on a large scale. The rainfall is abundant, the mountain systems are extensive, and the snow-fields of the Rocky Mountains and the uncounted lakes of the Eastern Plateau form vast natural reservoirs. Water-power is indeed one of the principal natural resources of the Dominion, and its development may, without exaggeration, be termed one of the romances of engineering industry.

The modern water-power industry began in Canada about 1895, and has shown a steady and remarkable growth which promises to be even more rapid in the future than in the past. During the last ten years, while the population increased 22 per cent., the developed water-power increased nearly 100 per cent. and its use in industry 245 per cent. The total water-power throughout the Dominion is estimated at over 18,000,000 horse-power, of which 3,227,414 horse-power is now developed, and 750,000 additional horse-power is under construction.

The capital invested in water-power development, transmission and distribution has grown from $121,000,000 in 1910 to $688,000,000 in 1923, and the opportunities for further investment in such enterprises are numerous and attractive. Natural resources are abundant, labour conditions are stable, agriculture and manufactures are increasing their yield, and new markets are being developed. The conditions in the central station, pulp and paper, mining and other industries, show their dependence upon water-power development.

The greatest part of the undeveloped water-powers of Canada belong to the Crown, either in the right of the Dominions, as in Alberta, Saskatchewan, Manitoba and the Territories, or in that of the provincial governments, as in the other provinces. The Crown grants issued under the various jurisdictions afford security of tenure and reasonable protection to capital, combined with such extent of control as is considered necessary in the public interest.

In some of the provinces developments have been made directly by Government agencies; in others private enterprise is alone responsible for the supply of hydro-electric energy. Each in its own sphere has given beneficial results.

* Extract of a paper read before the British Association for the Advancement of Science, at Toronto, by Mr. J. B. Challies, Director of the Water Power and Reclamation Service.

AGRICULTURAL RESEARCH AND FORESTRY IN THE FRENCH ZONE OF MOROCCO.

In the course of his Report on the economic and commercial conditions in the French Zone of Morocco, H.M. Consul at Casablanca points out that the Protectorate is rendering considerable services in this new country by its practical research work. Apart from several stud farms, it has five experimental farms—at Fez for cereals; near Mazagan, in "sahel" soil, for pasturage plantations and shrubs and trees; at Marrakesh to study

irrigation requirements of different cereals and trees: at Casablanca for vineyards, market gardens and pig breeding; and at Oudjda to study the breeding of mules.

At Rabat, Meknes, and Marrakesh experimental gardens exist for growing flowers, fruit, vegetables and trees, and at Sefrou a silk-worm farm is carrying on investigations. Every effort is made to bring all results to the notice of farmers.

Forests.—The forests of Morocco are now under the enlightened supervision of the Forestry Service, and their area is already on the increase. For centuries, however, the forests were wantonly destroyed. The area under the various trees is estimated as follows:—

	Acreage.
Argan tree (arar wood)	1,000,000
Thuya (conifer)	750,000
Cork, oak	650,000
Oak, green	500,000
Juniper, fir trees, etc.	500,000
Cedar (alone or with other trees)	400,000
	3,800,000

The cork and cedar are alone industrially exploited at present.

GENERAL NOTE.

Revival of Manaar (Ceylon) Pearl Fishery.—The Government of Ceylon has decided to revive the pearl fisheries near the port of Manaar on the north-west coast of Ceylon, and operations will probably be started in the autumn of this year. This is the first time, writes the United States Consul at Colombo, that pearl fishing has been attempted in the locality since 1908, when an unsuccessful expedition in the hands of a private fishing company was undertaken. It is believed that the fishery should be successful as the number of oysters is said to be very large and such pearls as have been procured are of fine quality.

Artificial Silk Industry in France.—Artificial silk manufacture in France has experienced a very rapid development in recent years. As early as 1911, when the production of artificial silk in the world was estimated at 5,000,000 kilos, France contributed more than 1,000,000 of the total. Since that time, however, writes the United States Commercial Attaché at Paris, the manufacture of this product has received a great impulse in other countries. Nevertheless, in spite of periodic fears that local manufacture may outrun its market, the French industry has continued to prosper, due in a large degree to the fact that natural silks have not increased greatly in supply, while the demand for silk textiles has constantly grown.

Australian Motor Trade.—A Melbourne correspondent, writing in the *Times Trade & Engineering Supplement*, of 28th June, says:—"The cheap American cars find favour in this country. The market is flooded with them, while commercial cars of similar origin are increasing in numbers to a surprising degree. During the past 12 months the number of motor chassis imported into the Commonwealth was 56,157. The value of these imports was £7,442,000. America contributed 27,765 chassis, valued at £3,743,950. Next in order was Canada, with 23,483 (£2,056,818), while the United Kingdom was third on the list with 2,007 chassis, worth £905,162. Imports from France numbered 1,189 valued at £265,226, and from Italy there were 1,281 cars of a value of £384,693. Imports from other countries were negligible, although of late German cars have reappeared on the market." With regard to the Australian motor-body building industry statistics show that the car importers have given a great fillip to the local trade. Chassis importers purchased from Australian body-builders 46,851 bodies, valued at approximately £3,279,570. During the year there were 13,941 bodies imported from America, 1,332 from Canada, 625 from the United Kingdom, 154 from France, and 148 from Italy. In April, 2,638 new motor vehicles were registered in Victoria alone.

Aerial Photography and Surveying.—In a paper read before the British Association for the Advancement of Science, at Toronto, Mr. A. M. Narraway, Controller of Surveys, stated that during the past two seasons considerable experimental work had been carried on in Canada in the utilisation of aerial photography for mapping purposes. The results obtained had enabled the Topographical Survey of Canada to apply these views in a practical and economical manner to supplement ground surveys. Marked progress had been made in mapping by oblique aerial photographs the important mineralised areas in Northern Manitoba and the intricate system of waterways in that district, and in obtaining information relative to forest cover by this means. Aerial photographs were also being used extensively in land classification, revision, and soil surveys.

The Severn Barrage Scheme.—Preliminary investigations to ascertain the feasibility of the scheme for using the tidal power of the Severn in the production of electrical power by the erection of a barrage across the river are to be proceeded with at once. The work has been entrusted to the Department of Scientific and Industrial Research and will be supervised and directed by a committee presided over by Mr. G. S. Albright, C.B.E., while Sir Maurice Fitzmaurice, C.M.G., F.R.S., and Sir John Purser Griffith, M.A.I., M.Inst.C.E., have been asked to submit a joint report before the end of this year as to the possibility of constructing a barrage on one or more of the sites suggested, on the assumption that safe foundations exist. The data provided by the geological and hydrographical investigations will be placed at the disposal of Sir M. Fitzmaurice and Sir J. P. Griffith.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.2.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

A STUDY OF THE DESTRUCTIVE DISTILLATION OF COAL.

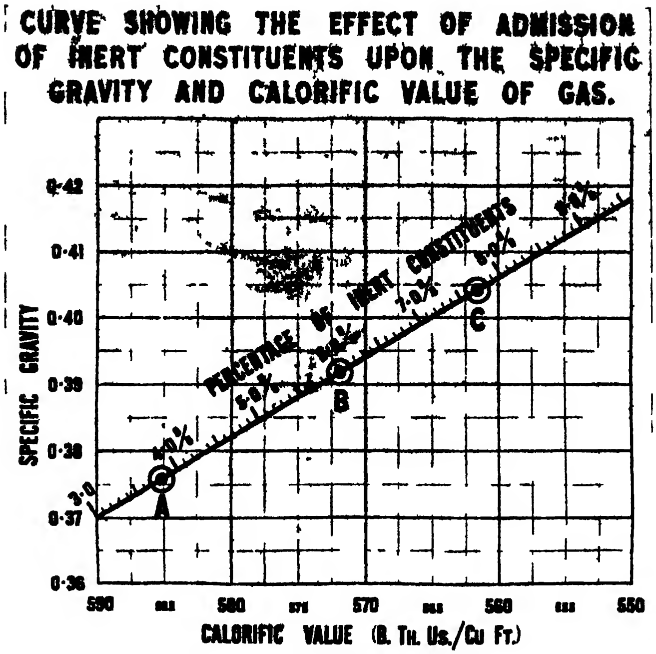
By EDWARD VICTOR EVANS, O.B.E., F.I.C.,
Chief Chemist and Products Manager, South Metropolitan Gas Company

LECTURE II.—*Delivered March 3rd,* 1924.

In the first lecture it was demonstrated that to determine only the gaseous thermal yield in the carbonising process was useless from the point of view of computing the efficiency of that process. It was shown that, though high gaseous thermal yields could be obtained with a hole in the retort or a leak in the mouthpiece, there was always a loss of true coal gas, the extra gas therms being made indiscriminately at the expense of another therm-containing constituent of the coal. It followed that the most economical results were to be attained by carbonising in a tight retort, and, if dilution were needed, by admitting a diluent gas under careful control.

Experience has shown that, if a system of very tight retorts is operated at a combustion chamber temperature of 1300°/1350° C. and maintained under a reasonable vacuum of $\frac{3}{10}''$ water gauge, the gas manufactured possesses the characteristics shown under A in Fig. 16. Such a gas contains so small a percentage of inert constituents and is consequently of so low a density and high calorific value that it is unsuitable for use in the inverted bunsen burner. There are many methods of adjusting the composition of this gas, as for example, by adding under control water gas, producer gas or waste gases. It was imagined that the least economic method would be to reduce the calorific value by raising the temperature of distillation, whereby undue degradation of the gas itself might result. It was decided, therefore, in the case in point, to add waste gases to the crude coal gas prior to purification. The effect on the calorific value and specific gravity of the gas of adding waste gases—*i.e.* inert constituents—is shown in Fig. 16. It was desired to add a proportion of waste gases sufficient to remove point A on the curve to B in order to produce a gas of 572 B.Th.Us. per cu. ft. which, upon subsequent admission of air to the purifiers, would be reduced to the desired calorific value, viz., 561 B.Th.Us. per cu. ft. The installation used for this purpose is shown in Fig. 17. A small exhauster drives the required volume of waste gases through the large meters shown in the illustration, and the quantity is very carefully controlled by reference to the recorded calorific value of the gas before and after treatment. Typical calorific value curves are shown in Fig. 18; the two upper charts indicate the nature of the gas made in the retort houses before adjustment and the lower chart the nature of the gas after dilution. It will be seen that a remarkably constant gas, from the point of view of calorific value, is delivered into the holders.

The great advantage of such an installation lies in the constancy of the thermal value of the gas and the close approximation to the declared calorific value which may be attained. This is not only of advantage to the consumer, but also to the gas manufacturer, who is frequently forced to supply a gas of calorific value materially higher than that declared, in order to be assured that the minimum calorific value never approaches the 6% penalty limit. The net result of operating the installation above described is to produce without marked degradation of gas or tar a 560 B.Th.Us. gas of very constant physical characteristics. No apparent increase in gaseous thermal yield has been observed and this is attributable to the fact that, when higher temperatures are maintained for the purpose of decomposing the gas down to the required standard, a certain degree of tar cracking takes place.



GAS ANALYSES

	A 585·1 B. Th. U. Gas %		B 571·8 B. Th. U. Gas %		C 561·4 B. Th. U. Gas %	
C_nH_m	3·23		3·16		3·10	
CO	7·30		7·13		7·00	
CH_4	31·08		30·35		29·80	
H_2	54·61		53·36		52·40	
CO_2	0·65	3·8%	1·05	6·0%	1·40	7·7%
O_2	0·2		0·2		0·2	
N_2	2·95		4·75		6·10	
Sp Gr	0·376		0·392		0·404	

Fig 16.

This does not occur with the adjustment plant in operation and in consequence a higher yield of tar is obtained. Whether or not it is advantageous to crack tar into gas is a question of economics which will receive consideration later, but the point to be made at this stage is that, whereas it has been shown in the first lecture that the thermal yield of gas alone is of no use in computing the efficiency of the process, the conclusion is now arrived at that, as the therms of tar and gas are interchangeable, no true appreciation of results may be obtained unless the thermal value of tar be also taken into account. In controlling the carbonising process, it is necessary, therefore, to determine not only the yield of gas therms, but also that of tar therms, and it is convenient to class these together under the heading of "volatile therms." Results of working may thus be expressed as follows: There has been obtained a total yield of 90 volatile therms of which 73 are in the form of gas.

In this lecture it is proposed to deal solely with the very close relationship existing between gas and tar, as the author does not think this subject has in the past received sufficient attention from the gas industry.

The introduction of the therm system has rendered practically useless the investigations of men in the gas industry who have expressed their results in terms of cubic feet of gas of a certain illuminating power per ton of coal. This is to be regretted, but it is the result of circumstances. The absence of data relating to the calorific value of the tar recovered is not so serious an omission since if the yield of tar be known an average figure may be taken for the purpose of ascertaining a very approximate tar thermal

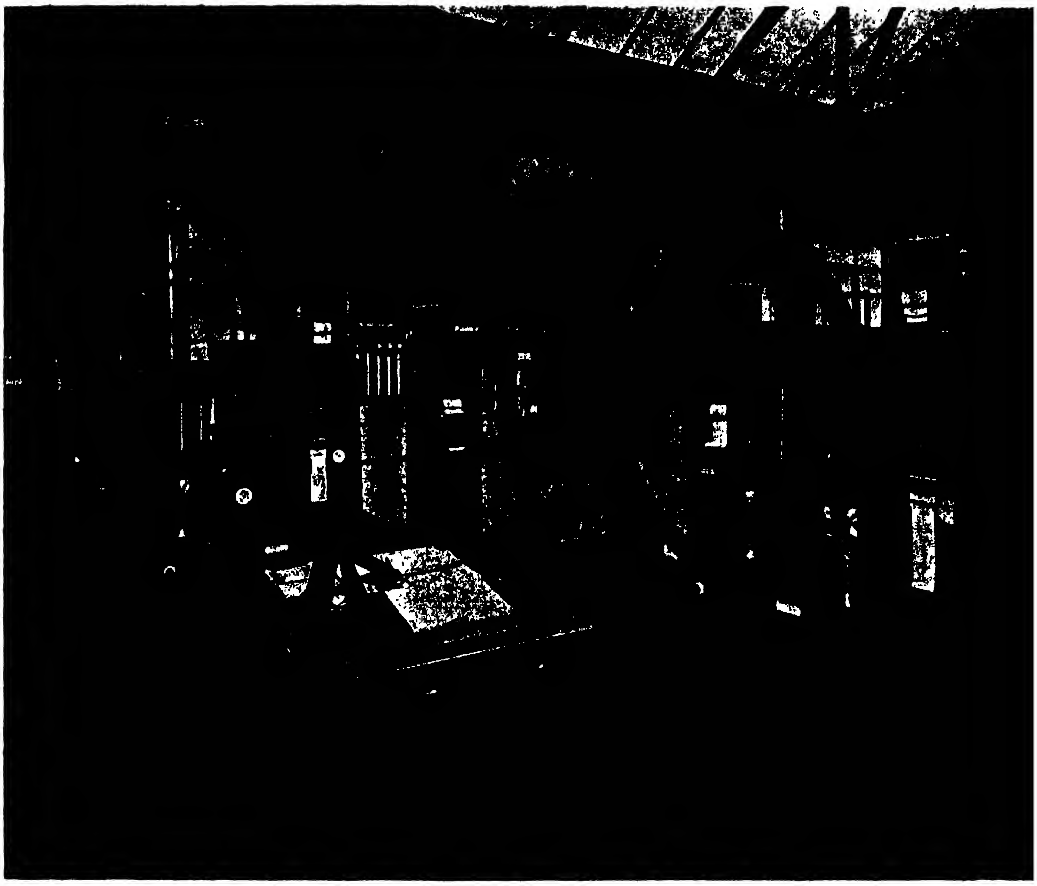
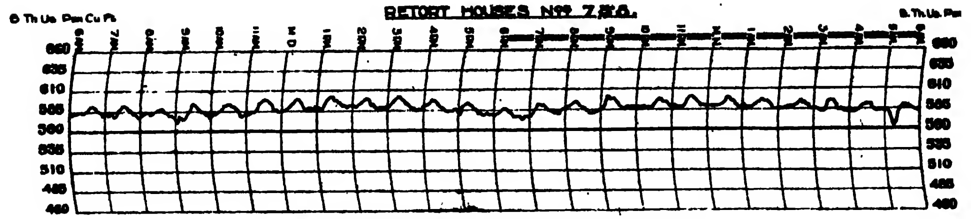


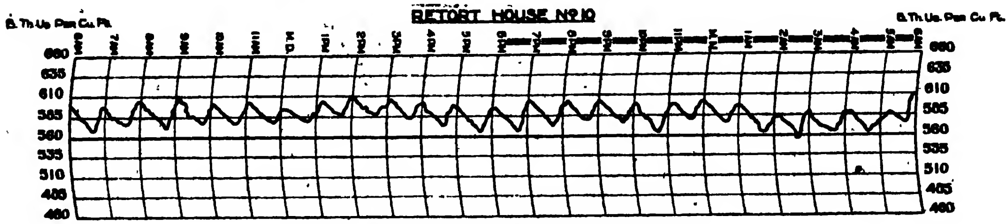
Fig. 17.

yield, but the fact that investigators have failed to note the volume and nature of tar recovered, when studying the effect of varying conditions upon the carbonisation process, shows a lack of appreciation of the part that may be played by tar. The results of sound investigations in the gas industry to be of any value must be expressed upon the basis of the thermal yield of each of the products, gas, tar, and coke, but many of the reports, dissertations and claims appearing in the gas literature of to-day are entirely misleading, as they are made by investigators who have failed to appreciate the thermal interrelation between the three products derived from the carbonisation of coal. While one Works is able to obtain 80 therms of a gas which is obviously not true coal gas, another obtains a high yield of a gas the analysis of which indicates that it must have left behind pitch instead of tar. No data, however, are given concerning the yield and nature of the resulting tar, so that it is impossible to obtain any accurate conception of the efficiency of the carbonisation process. If one is looking for high gaseous thermal yields and if the whole of the volatile matter is expelled from the coke, then there is a certain limit beyond which gas must be manufactured at the expense either of coke or tar, and the investigator who, in studying the effect of certain carbonising conditions, overlooks this, paints only half a picture and obtains results which bring little enlightenment to the gas industry. The importance of considering the yield of volatile therms will be apparent when it has been demonstrated how this yield and the proportion of gas therms to tar therms are affected by the nature of the distillation process.

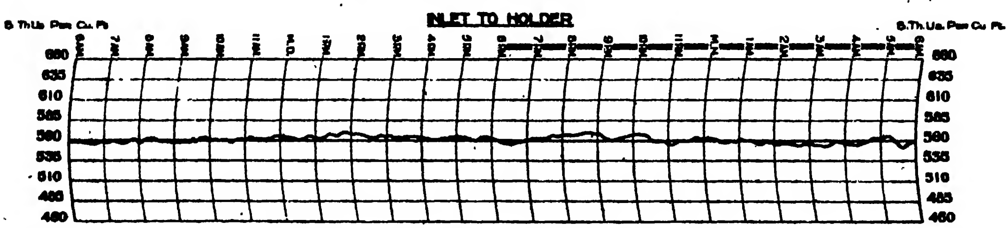
The results of an investigation carried out to determine the effect of the rate at which the coal charge is heated upon the relation between the yields of gas therms and tar therms will now be examined. The results



MEAN CALORIFIC VALUE 588 B.Th.Us. Per Cu. Ft.



MEAN CALORIFIC VALUE 588 B.Th.Us. Per Cu. Ft.



MEAN CALORIFIC VALUE 560·4 B.Th.Us. Per Cu. Ft.

Fig. 18.

of this investigation are embodied in Table A. These tests have been carried out upon only 100 grammes of coal, but to secure uniformity, a large sample has been finely ground and small briquettes have been made of the mixture (under pressure without binding material) for the purpose of obtaining homogeneous samples. The author is well aware that carbonising trials on such a small scale are likely to be misleading. These results in so far as they relate to the points in question, are generally in accord with Works practice and it is on this account that they may be considered to possess technical interest.

The coal used in these small scale carbonising trials was a typical Durham coal, the analysis of which is shown in the next column.

—	Natural Basis	Ash & Water Free Basis.
	P.Ct.	P.Ct.
Volatile matter (American test)	35.5	
Ash	5.13	
Moisture	1.42	
Calorific value, B.Th.U. per lb.	14,460	
Ultimate analysis—		
Carbon	79.98	85.59
Hydrogen	4.73	5.06
Nitrogen	1.22	1.31
Sulphur	1.69	1.81
Oxygen	5.83	6.23

The apparatus used consisted of a silica retort 2" in diameter and 24" in length, packed at its closed end with asbestos. This retort was charged with five cylindrical briquettes placed end to end within the central portion of the retort, the total combined length of the briquettes being approximately 7". A pyrometer was fitted to the retort and the latter was either plunged into a fully heated furnace or introduced into a cold one which was gradually heated to the required temperature over a definite period; the final temperature attained within the retort was the same in all cases. A sectional view of the furnace is shown in Fig. 19, while Fig. 20 is a photograph of the whole apparatus. For the purpose of this lecture and until a detailed description of the work is published, the author wishes it to be assumed that the construction of the apparatus, and its manipulation, together with weighing and analytical

FURNACE USED IN THE CARBONIZATION OF BRIQUETTED COAL AT VARYING RATES

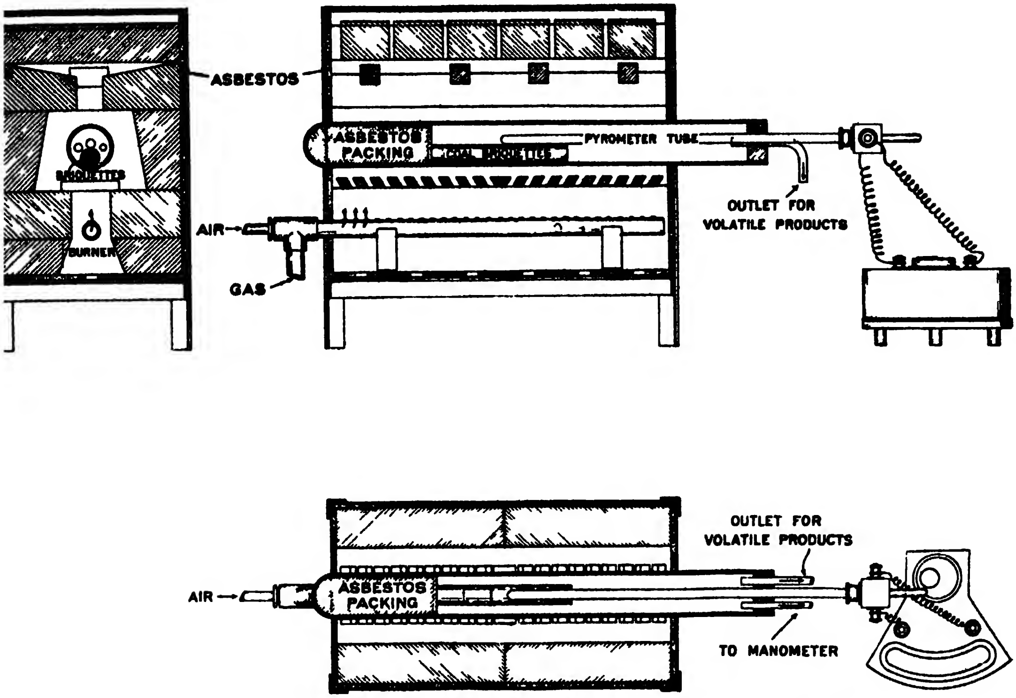


FIG 19

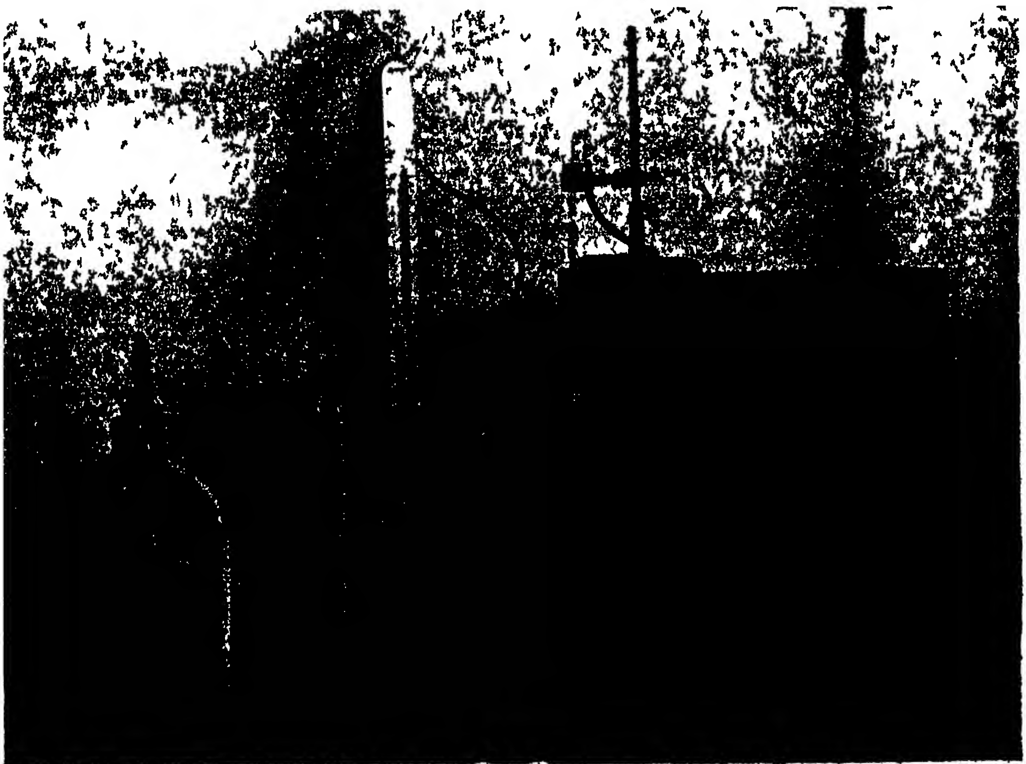


FIG. 20.

operations, were carried out in an approved manner.

It will be observed from Table A that the final temperature attained in this series of carbonisations was 1000°C., but that the time taken to attain this temperature varied from 18 minutes to 13 hours. In the first experiment the retort was placed in a furnace already heated to 1000°C. In this respect this experiment differed from the remaining carbonisations, in which the furnace was gradually heated up until a temperature of 1000°C. was attained in the retort within the required time. An important point to be made is that, however quickly the final temperature, as observed by the pyrometer, was reached, the carbonising process was always practically finished at this stage, and though each test was extended for some time after the final temperature was attained, the quantity of the products distilled was found to be small. In computing the results of all experiments, a correction has been made for the residual gas in the retort and other apparatus at the end of the experiment by adding 1.5 therms per ton to the yield of therms calculated from the volume of gas actually collected and its calorific value. This figure of 1·5 was based upon an experimental determination of the approximate composition and volume of the residual gas.

The following points will be noticed from an examination of the table :—

(1) The yield by weight and the total thermal content of the coke increase slightly as the rate of heating decreases.

(2) The tar by weight and thermal content increases rapidly to a certain maximum and then falls off.

(3) The thermal yield of gas falls rapidly as the rate of heating decreases, until a certain limit is reached beyond which there is no further reduction.

(4) The carbon and pitch (which is the material other than coke left in the retort after the test) falls to a minimum both in weight and thermal content, but again rises with exceedingly slow carbonisation.

It will now be of interest to study the relationship existing between gas therms and tar therms and the effect of the rate of carbonisation upon the total number of volatile therms produced. The two most important observations to be made in this connection are :—

(1) The total volatile therms computed by adding together tar therms and gas therms, show a gradual decrease as the rate of carbonisation becomes slower, there being a marked decrease in the case of exceedingly slow carbonisation. There is thus a lower, rather than a higher, yield of volatile therms resulting from the slow and careful carbonisation of the charge.

(2) Although the yield of total volatile therms falls but gradually with a reduction in the rate of carbonisation, the ratio of gas therms to tar therms undergoes considerable variation. It will be observed that whereas rapid carbonisation favours the production of gas, slow carbonisation up to a point has the effect of preserving tar yields.

As the first of these observations appeared to be contrary to preconceived ideas of carbonisation, it was proposed to carry out the carbonisation in two stages, for the purpose of ascertaining whether this more careful method of carbonisation would still give a low yield of volatile therms. Table B shows the results thus obtained.

In these tests the same type of coal and the same apparatus were used as in the first series of carbonisations. Carbonisation was, however, effected in two stages, a temperature of 525°C. being attained in the first stage. This temperature was maintained until no further volatile matter was expelled and the residue was then heated up to 1000°C. to complete carbonisation. The preliminary temperature of 525°C. as well as the final temperature of 1000°C. was attained in varying times in the three experiments. From the results it is obvious that this two-stage distillation process is a more careful—*i.e.* a less drastic—carbonising process. It is less drastic in that there is obtained an abnormally high yield of tar, very little carbon and pitch and a yield of gas therms which is quite poor when considered in the light of to-day's working result. It will be observed that the percentage of unsaturated hydrocarbons in the final gas is low. The total yield of volatile products is, however, of the same order as the yields obtained in the moderately slow carbonisations of the first series of experiments.

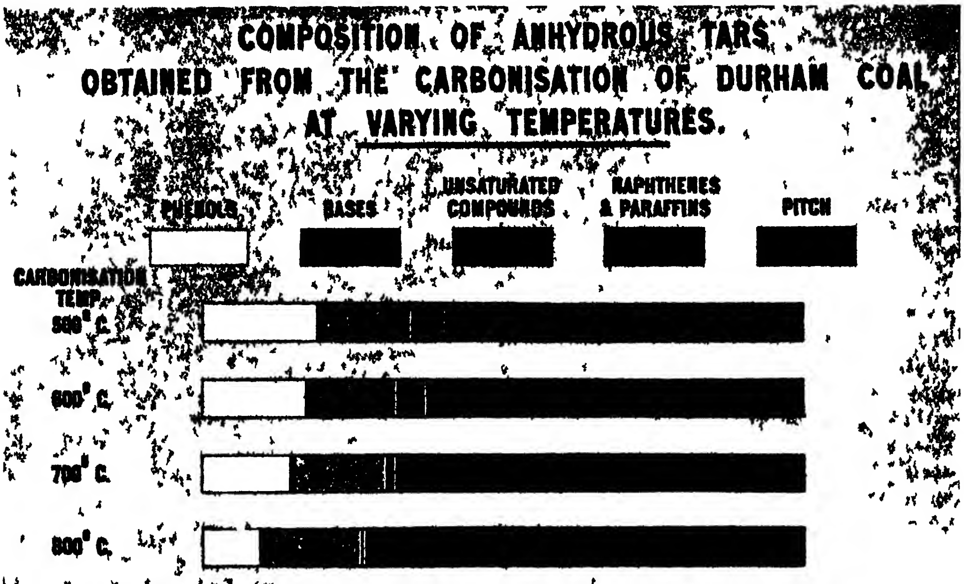
It is a remarkable fact that under conditions of careful and slow heating the yield of volatile therms obtained should be so low, but this observation forms the basis of important conclusions to be developed subsequently. The first hypothesis which was

suggested to explain the results obtained was that some molecular rearrangement of the coal substance itself took place at a moderately low temperature, before true carbonisation commenced, and that on this account the coal became less suitable for gas manufacture. The author is, however, now convinced that a very much simpler explanation lies in the suggestion that when the coal is very slowly distilled there occurs simultaneously a fractional distillation of the tar, with the consequent formation of pitch. An observation which tends to confirm this hypothesis is that the tar obtained is a limpid brown liquid containing a very small proportion of pitch and practically no free carbon and when the carbonisation process is very protracted, it is comparatively small in quantity. Further, such a hypothesis would account for the considerably augmented coke yield, as well as for the increase in the quantity of pitch and carbon found in the retort, which otherwise would be inexplicable after such special precautions had been taken to carry out a very careful distillation of the coal. There is much more evidence to support this hypothesis which will be presented at a later stage.

The second important conclusion which resulted from a study of these experiments will now be considered—*i.e.*, that the more rapid the carbonisation the greater the thermal yield of gas. It is evident that the additional gas produced during rapid carbonisation results principally from the cracking of tar within the retort. This decomposition of the tar is at its maximum in the case of the most rapid heating, as may be seen also from an examination of the nature of the gas produced. The most outstanding characteristic of the gas is the high proportion of unsaturated hydrocarbons—a fact which points to the judicious decomposition of tar. It is of interest to note, however, that tar cracking—to the extent to which it is practised in these experiments—appears to proceed without any appreciable loss in therms, for it will be seen from Table B that, for all practical purposes, it may be said that the therms lost from the tar are approximately recovered in the gas. These results dispose of the objection to horizontal retort working which has been put forward by those interested in promoting a slow and more careful method of distillation. This objection is founded upon a belief, which the author knows to be mistaken, that the rapid heating of coal is very wasteful of thermal energy.

The outstanding conclusion to be drawn from this work is that there is a tendency for the highest volatile therm yield to be obtained by practising the most rapid heating possible, and, while such a condition is certainly conducive to high gaseous therm yields, slower and more careful distillation is a tar conserving process and exceedingly slow distillation a coke conserving one. Beyond this, the work is only of academic interest, as the conditions of these experiments are not directly comparable with large scale working of to-day. The excellent yields of volatile therms obtained in these experiments are explicable and have formed the basis of further investigations of the principles of obtaining enhanced yields of volatile therms.

Returning to the important question of the extent to which tar may be profitably cracked into gas, certain chemical aspects of the mechanism of tar cracking should be presented. By this means it is possible to demonstrate that there is a certain limit to the quantity of gas which may be produced from tar, the over-stepping of which limit results in the deterioration of the tar to such an extent that the process becomes untenable from many points of view. It is almost unnecessary to explain that in the production of gas at the expense of tar—an operation which is proceeding to a varying extent at all stages of coal distillation—it is not a certain proportion of the tar which is changed into gas, leaving the remainder unchanged, but the character of all the tar is entirely altered, as regards both its physical properties and chemical constitution. The brown limpid fluid obtained under conditions of slow heating is replaced under the conditions of rapid heating and high temperatures by a thick black tar, which becomes more and more viscous with increasing decomposition. These points are very well developed in Fig. 21, which shows the analyses of tars obtained from the carbonisation of a Durham coal at increasing temperatures. It is apparent that with increasing temperatures the naphthenes, paraffins and phenols gradually disappear, while the pitch content is appreciably augmented. Another point of considerable interest, which may be seen from the table in that diagram, is the degree of decomposition which has taken place in the pitch as exemplified by its free carbon content, which is 8.6% in 500°C. tar and as much as 36.1% in 800°C. tar.



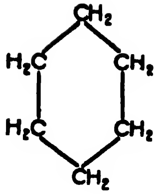
CHARACTERISTICS OF PITCH

CARBONISATION TEMPERATURE °C	FREE CARBON %	SOFTENING POINT °C
500	8 6	30 0
600	12 8	48·1
700	18 5	72·2
800	36 1	97·0

FIG 21.

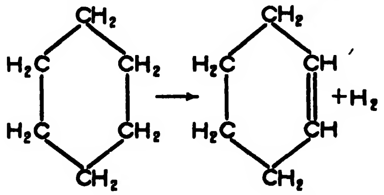
The tar obtained from a low temperature distillation may now be regarded as primary and that from a high temperature distillation as secondary Considerable work is being carried out by investigators at the present moment in connexion with the constitution of these primary tars, and some of the work is leading to such interesting conclusions and would form such a delightful subject matter for lectures, that the author has almost been tempted to incorporate some of it in the present series There is, however, little satisfaction in presenting the work of others and it is suggested that those who are interested should make themselves acquainted with the work of these investigators

The most important class of compounds present in primary tar consists, as first shown by Pictet and his collaborators, of hydrocarbons of the closed ring type similar to those found in petroleum. They may be either fully saturated, as cyclohexane (C_6H_{12}), or only partly saturated, as cyclo hexene (C_6H_{10}), and in order to attempt to trace the mechanism of tar cracking it is proposed to consider in detail the effect of heat upon these two hydrocarbons which may be regarded as typical of other members of the same series The cracking of cyclo hexane forms a very interesting picture of the complicated nature of the multitudinous reactions which take place in the thermal decomposition of a primary tar Complex though the reactions are, they are not so complex as in the case of the decomposition of phenols by heat, for cyclohexane only contains atoms of carbon and hydrogen in the molecule, while the phenols possess also one or more oxygen atoms In the case of cyclohexane, the six carbon atoms in the molecule are linked together in the form of a ring, each carbon atom being attached to two other carbon atoms and two hydrogen atoms It is hexa hydrobenzene, C_6H_{12}



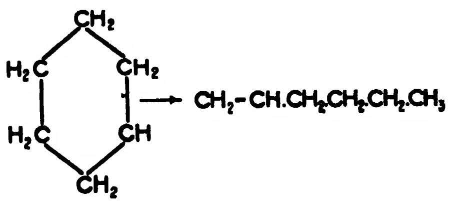
This is usually regarded as a most stable grouping and, in fact, cyclohexane is found to be specially resistant to attack by most chemical reagents. Resistant though it may be to chemical attack, the molecule becomes very unstable at high temperatures, and from this one chemical compound there may originate innumerable compounds, solid, liquid and gaseous. The thermal decomposition of cyclohexane has been studied by several workers (notably by D. T. Jones) and a detailed study has also been made by the author of the liquid and gaseous products of decomposition. This experimental work has formed the basis of a diagram representing the course of decomposition of this hydrocarbon; though some of the reactions indicated may be hypothetical, they are based as far as possible on facts supported by experimental evidence. The object of presenting this imaginative picture is to allow some small appreciation of the innumerable reactions likely to take place in a retort at any one moment.

A large number of the possible reactions which may be conceived to take place in the decomposition of cyclohexane by heat are grouped together in Fig. 22. The decomposition appears to commence either with the elimination of hydrogen, forming the com-



CYCLOHEXENE.

pound cyclohexene, or by direct fission of the ring, when molecular rearrangement will take place resulting in the formation of an



open chain hydrocarbon of the unsaturated type, as for example, the olefine n. hexylene.

(A kinematograph film showing the decomposition of cyclohexane to cyclohexene and to n.hexylene was thrown on the screen).

The two reactions proceed simultaneously, and probably with similar velocities. The two products of decomposition, n.hexylene and cyclohexene, may undergo further decomposition on heating. In the first place, the possible course of the decomposition of the n.hexylene is considered. Using the conception of $(CH_2=)$ residues originated by Prof. Bone, it may be imagined that this hypothetical group becomes separated from the rest of the molecule by breaking of the double bond—a special point of weakness in the molecular structure—and that the remaining portion then undergoes rearrangement with the formation of the lower olefine amylene

$$
\begin{gathered}
CH_2{=}CH.CH_2.CH_2.CH_2.CH_3.\\
\rightarrow CH_2{=}CH.CH_2.CH_2.CH_3+(CH_2{=}\\
\text{Amylene.}
\end{gathered}
$$

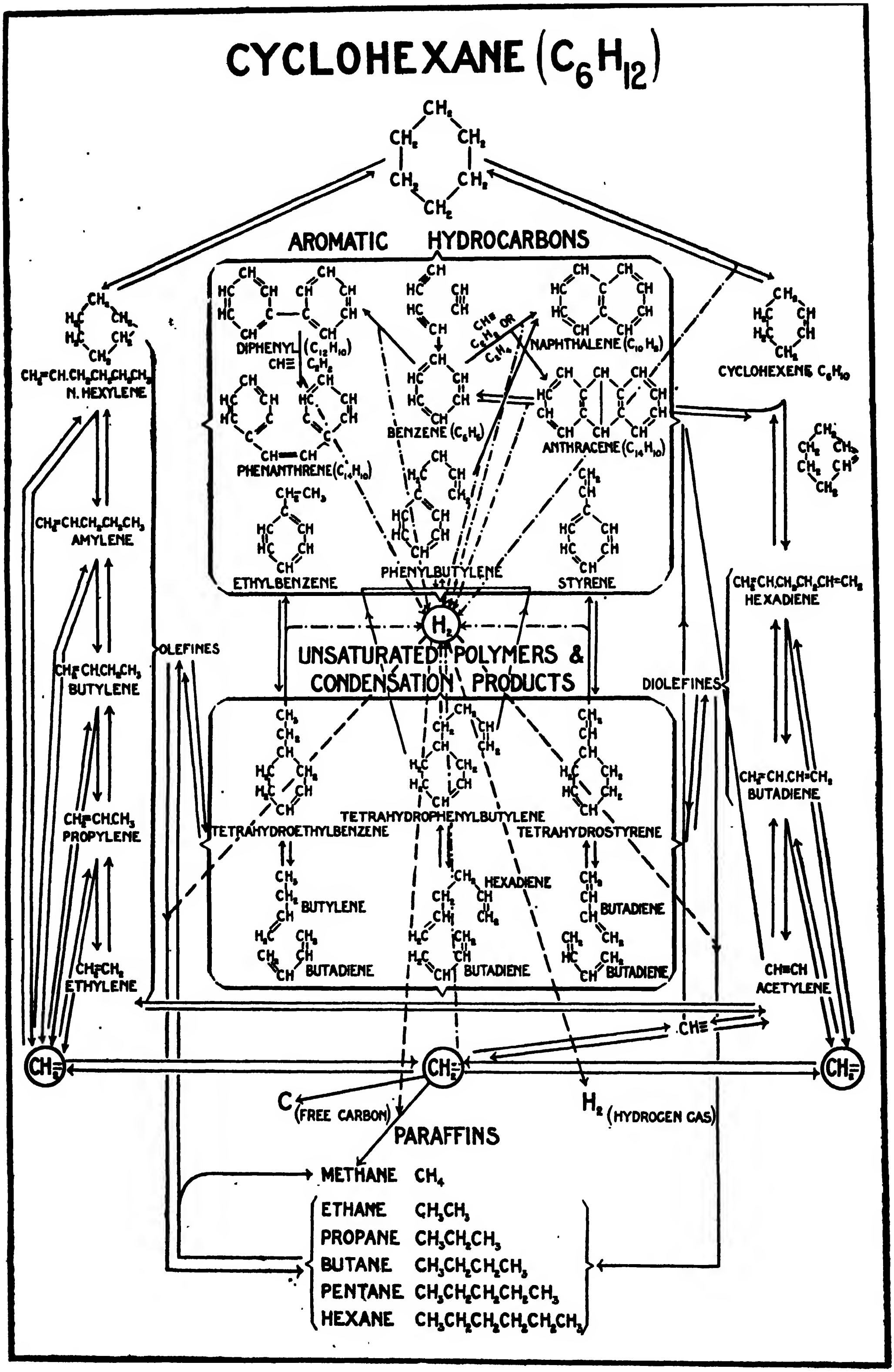
(This reaction was illustrated by a film.)

Amylene itself may similarly be decomposed with the formation of butylene; and this in turn may give rise to propylene and then to ethylene. Ethylene may finally decompose into two $(CH_2=)$ groups.

$$
\begin{array}{ll}
CH_2{=}CH.CH_2.CH_2.CH_3 & \\
\rightarrow CH_2{=}CH.CH_2.CH_3 & +(CH_2{=})\\
\quad\text{Butylene} & \\
CH_2{=}CH.CH_2.CH_3. & \\
\rightarrow CH_2{=}CH.CH_3 & +(CH_2{=})\\
\quad\text{Propylene} & \\
CH_2{=}CH.CH_3 & \\
\rightarrow CH_2{=}CH_2 & +(CH_2{=})\\
\quad\text{Ethylene} & \\
CH_2{=}CH_2 & \\
\rightarrow (CH_2{=}) & +(CH_2{=})
\end{array}
$$

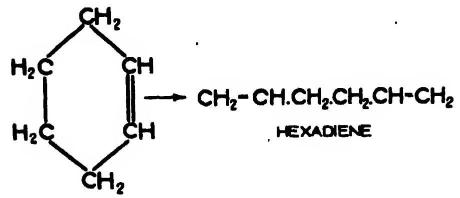
It should be pointed out at this stage that these $(CH_2=)$ residues would be too unstable to exist as such; they would necessarily be very reactive and become involved in other reactions which will be mentioned later. They are, however, especially useful, as Bone has previously shown, in constructing a picture of the mechanism of hydrocarbon decomposition.

Returning to cyclohexene—the primary product in the alternative method of decomposition of the original cyclohexane—this


CYCLOHEXANE (C_6H_{12})
AROMATIC HYDROCARBONS
DIPHENYL ($C_{12}H_{10}$)
NAPHTHALENE ($C_{10}H_8$)
BENZENE (C_6H_6)
ANTHRACENE ($C_{14}H_{10}$)
PHENANTHRENE ($C_{14}H_{10}$)
ETHYLBENZENE
PHENYLBUTYLENE
STYRENE
CYCLOHEXENE C_6H_{10}
N. HEXYLENE
AMYLENE
BUTYLENE
PROPYLENE
ETHYLENE
OLEFINES
HEXADIENE
BUTADIENE
ACETYLENE
DIOLEFINES
UNSATURATED POLYMERS & CONDENSATION PRODUCTS
TETRAHYDROETHYLBENZENE
TETRAHYDROPHENYLBUTYLENE
TETRAHYDROSTYRENE
C (FREE CARBON)
H_2 (HYDROGEN GAS)
PARAFFINS
METHANE CH_4
ETHANE CH_3CH_3
PROPANE $CH_3CH_2CH_3$
BUTANE $CH_3CH_2CH_2CH_3$
PENTANE $CH_3CH_2CH_2CH_2CH_3$
HEXANE $CH_3CH_2CH_2CH_2CH_2CH_3$

compound cannot resist further decomposition, owing to the presence of the double bond. The major portion, through fissure of the ring at the double bond and rearrangement of the molecule, is converted to open chain unsaturated compounds. The initial product is probably the diolefine hexadiene, and this may be expected to undergo further decomposition, splitting off ($CH_2=$) residues, and giving rise in turn to butadiene and finally acetylene.

(*A film depicting the decomposition of cyclohexene to hexadiene was shown.*)



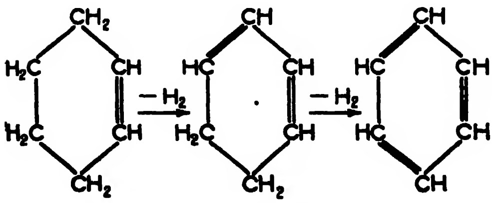
$$CH_2{=}CH.CH_2.CH_2.CH{=}CH_2$$
$$\rightarrow (CH_2{=}) + CH_2{=}CH.CH{=}CH_2 + (CH_2{=})$$
Butadiene.

$$CH_2{=}CH.CH{=}CH_2$$
$$\rightarrow (CH_2{=}) + CH \equiv CH + (CH_2{=})$$
Acetylene.

The acetylene may then break down either to the hypothetical ($CH \equiv$) residues or finally to carbon and hydrogen.

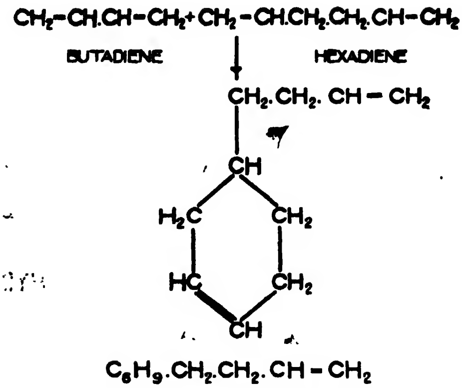
$$CH \equiv CH \rightarrow (CH \equiv) + (CH \equiv)$$
$$CH \equiv CH \rightarrow 2C + H_2$$

A smaller portion of the cyclohexene undergoes loss of hydrogen, resulting ultimately in the formation of benzene. Dihydrobenzene possibly represents a transition stage.



CYCLOHEXENE. DIHYDROBENZENE. BENZENE.

Simultaneously with the other reactions already described, it would appear that some polymerisation and condensation of the unsaturated molecules take place, resulting in the formation of high boiling point unsaturated bodies and aromatic compounds. For example, it is possible to conceive that butadiene and hexadiene may unite to produce tetrahydrophenylbutylene,



TETRAHYDROPHENYLBUTYLENE

which on dehydrogenation may give phenylbutylene

$$C_6H_9.CH_2.CH_2.CH{=}CH_2 \rightarrow$$
$$C_6H_5.CH_2.CH_2.CH{=}CH_2 + 2H_2$$
Phenylbutylene.

This compound is well known to be capable of condensing to naphthalene, with the elimination of hydrogen.

$$C_6H_5.CH_2.CH_2.CH{=}CH_2 \rightarrow C_{10}H_8 + 2H_2.$$

(*A further film showed the formation of naphthalene from butadiene and hexadiene.*)

Before leaving the olefines already referred to, it must be pointed out that these may be hydrogenated to paraffins. A glance at Fig. 22 (in which the hydrogen evolved or absorbed in the various reactions is indicated by dotted lines) will show that there is always present for this purpose sufficient hydrogen produced during the reactions of decomposition. In this way, hexylene may be converted to hexane, and similarly, pentane, butane, propane and ethane may be formed from the corresponding unsaturated hydrocarbons.

$$CH_3.CH_2.CH_2.CH_2.CH{=}CH_2 + H_2$$
Hexylene.
$$\rightarrow CH_3.CH_2.CH_2.CH_2.CH_2.CH_3$$
Hexane.

A reverse change may, however, take place, resulting in the formation of methane and an olefine containing one carbon atom less than the original paraffin. For example, hexane may give rise to amylene and methane.

$$CH_3.CH_2.CH_2.CH_2.CH_2.CH_3$$
$$\rightarrow CH_2{=}CH.CH_2.CH_2.CH_3 + CH_4$$
Amylene. Methane.

The hypothetical ($CH \equiv$) and ($CH_2{=}$) residues which have been assumed to be produced at various stages of the decomposition, together with a considerable quantity of hydrogen, may undergo interaction or

decomposition, with the formation of compounds such as the following :—

(*a*) Methane
$(CH_2=)+H_2 \quad \rightarrow CH_4$

(*b*) Ethylene
$(CH_2=)+(CH_2=) \quad \rightarrow CH_2=CH_2$

(*c*) Acetylene
$(CH\equiv)+(CH\equiv) \quad \rightarrow CH\equiv CH$

(*d*) Benzene
$6(CH\equiv)$
or $3\ CH\equiv CH \quad \rightarrow C_6H_6$

(*e*) Naphthalene
$C_6H_6+ \begin{matrix} 4(CH\equiv) \\ \text{or} \\ 2CH\equiv CH \end{matrix} \quad \rightarrow C_{10}H_8+H_2$

(*f*) Carbon and Hydrogen
$(CH_2=) \quad \rightarrow C+H_2$

portions of free carbon and gas increase with the temperature, while the liquid decomposition products become more aromatic in character. The insignificant amount of benzene produced calls for attention. When the temperature is sufficiently high, complete degradation to carbon and hydrogen may take place. From this picture it is evident that a whole series of both analytical and synthetical reactions are in progress during the decomposition of cyclohexane by heat. When it is realised that, in the first place, cyclohexane is not nearly so complex as most of the other constituents of primary tar, and, secondly, that it is only one of the innumerable compounds present in that tar, no apology will be required from the chemist for his inability to gain anything but the haziest notion of what is taking place in the retort.

PRODUCTS OF DECOMPOSITION OF CYCLOHEXANE AT VARIOUS TEMPERATURES

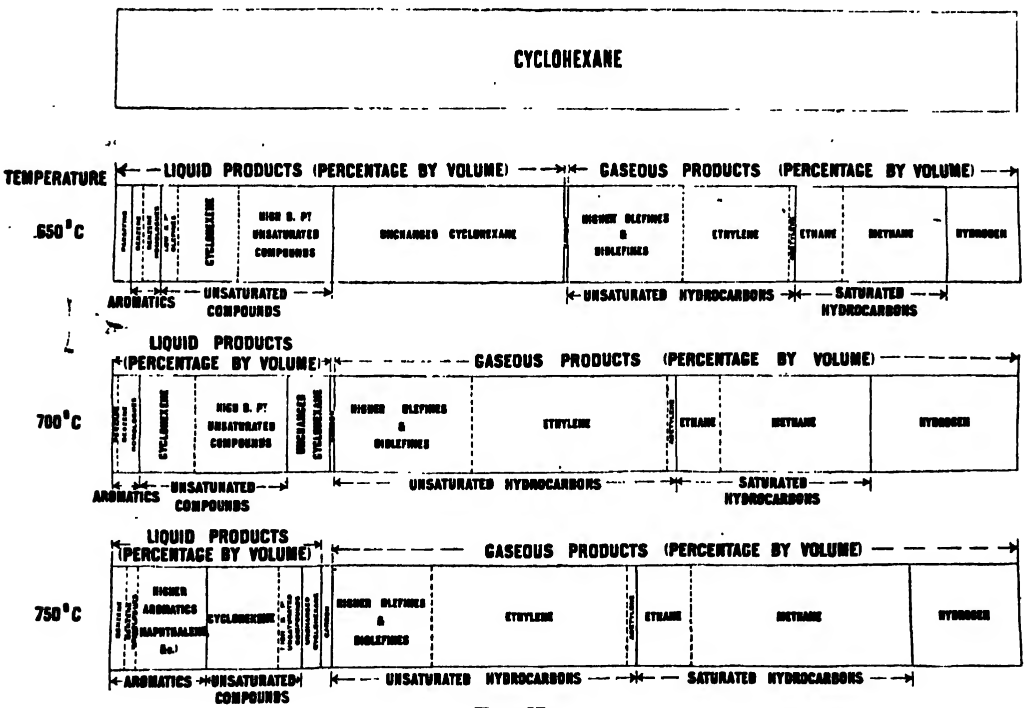


FIG. 23.

The relative proportions in which these various decomposition products are present will be considerably influenced by the temperature at which the cracking takes place. The accompanying diagram (Fig. 23) shows approximately the relative proportions of the important products formed at three different temperatures, 650°, 700° and 750°C. It will be noted that the pro-

Our experiments, though perhaps indicating a slightly different interpretation of the mechanism of cracking of cyclohexane from that suggested by other investigators lead to the same general conclusions :—

(1) Hydrocarbons of the cyclohexane and cyclohexene type are the main gas

yielding constituents of primary tar. The gas resulting from their decomposition is rich in unsaturated compounds, together with ethane and methane, and is consequently of high calorific value.

(2) The higher aromatic compounds, such as naphthalene, anthracene, etc., are formed to an appreciable extent by the polymerisation and condensation of the unsaturated compounds present in the gaseous decomposition products.

(3) Direct dehydrogenation, with the formation of benzene and its homologues takes place only to a very small extent, insufficient to account for the quantity of these compounds present in high temperature tar.

It will have been seen that cyclohexane lends itself admirably to the cracking process and it is probable that the gas industry depends greatly upon the cracking of hydrocarbons of this type for the production of gas sufficiently rich to allow of the subsequent admixture of water gas without unduly lowering the calorific value below that requisite for economic distribution. It is probable that such hydrocarbons as cyclohexane are selectively cracked in the decomposition of primary tar, leaving a residue of secondary tar which is less suitable for further cracking. This question of the cracking of primary and secondary tars has been studied in a series of experiments in which high and low temperature tars have been cracked in a somewhat artificial way in the laboratory. In these experiments the tars have been heated to various temperatures and their vapours cracked over heated coke in the presence of nitrogen or coal gas. Though the results of these experiments are presented, it is beyond the wit of man to interpret the results obtained in terms of the actual chemical reactions which have taken place.

FURNACE USED IN TAR CRACKING EXPERIMENTS.

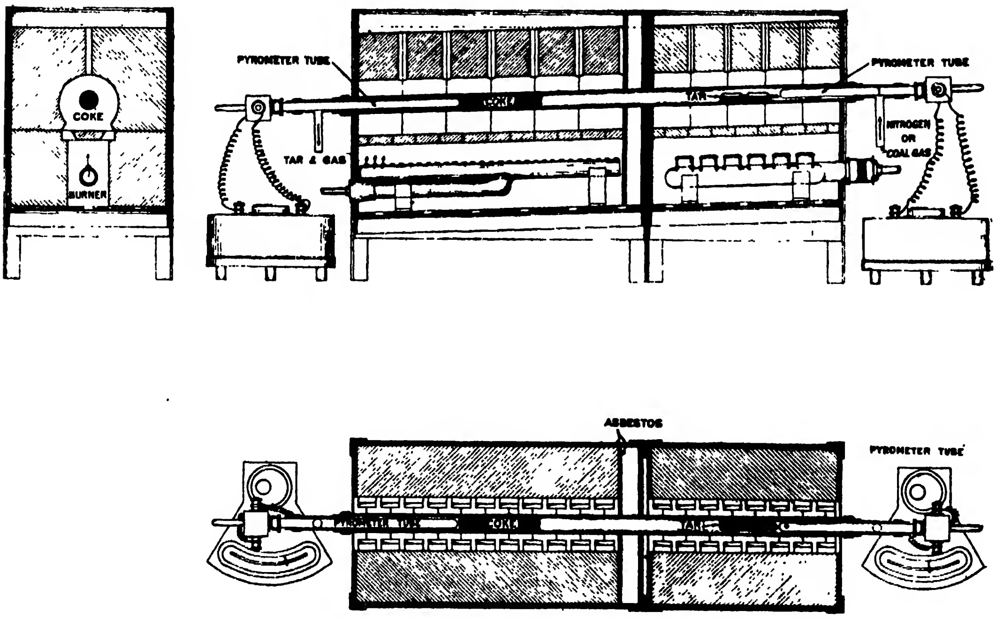


Fig. 24.

The apparatus used is illustrated in Fig. 24. A silica tube 36" long was heated by two separate furnaces so that the two parts of it could be maintained at different temperatures. In one portion of the tube was placed a boat containing 10 grammes of tar and in the other a quantity of coke to act as a heated contact material for the cracking of tar. A stream of nitrogen or coal gas was passed slowly through the tube from the tar boat end, and the gases and condensable liquids were conducted away from the opposite end. The method of procedure

was first to heat the coke to a definite temperature, and then to raise the contents of the boat to a similar temperature over a period of either two or four hours. Representative samples of low and high temperature tars were used in these experiments and the results obtained are indicated in Tables C and D. It will be readily appreciated that the conditions of these experiments are very dissimilar to those which may be experienced during the cracking of tar in the carbonisation process on a large scale. Notwithstanding this, the results are of considerable interest.

As regards low temperature or primary tar, it will be seen that a fair yield of gas is obtained at temperatures as low as 600°C., a large proportion of the tar being recovered as a liquid which is of the nature of secondary tar. The figures relating to the quantity of tar recovered refer only to the tar condensed and do not include the residue in the boat. The residue obtained in the case of low temperature decomposition was a pitch-like coke, while that remaining at higher temperatures was virtually a coke containing practically no volatile matter. The yield of gas and tar recovered at 600°C is of the order of 62—74%, whereas at 800°C. the yield is less satisfactory. At 980°C. the process has already become poor from the point of view of total yield—the efficiency of cracking to tar and gas having been reduced to 30—40%. The tar recovered at this temperature is small in quantity and is of an inferior quality, being thick and viscous. Moreover, it is evident from the gas analyses that with increasing temperatures the gas itself has suffered considerable deterioration, the hydrocarbons having been largely decomposed, and the hydrogen percentage materially increased. The gas made at the lower temperatures is rich in saturated and unsaturated hydrocarbons and poor in hydrogen. The vital necessity of clearing the rich gas from the retort as quickly as possible and avoiding long contact with heated surfaces is clearly demonstrated in the experiment at 700°C. where an extension of the duration of the experiment from two to four hours results in a considerable degradation of the gas, the unsaturated hydrocarbons alone having decreased from 9 to 2.6%.

In dealing with the results obtained from the cracking of high temperature tar, it will be seen that the yields by weight of gas and tar at 1000°C. only amounted to 20%, while only 25% of the thermal value of the tar was recovered as gas—and very poor gas too. But, above all, it should be noted that the residual tar obtained by this procedure was little else than free carbon. In all cases of the cracking of this high temperature tar the gas consists mainly of hydrogen. Only a small percentage of unsaturated hydrocarbons is present, and methane is also a much less important constituent than in the gas from low temperature tar.

The conclusion that should be drawn from these experiments is that, directly a primary tar has been converted by cracking to secondary tar, it should be removed from the retort as quickly as possible, as the high temperature tar is a most unsuitable material to be submitted to the cracking process. The compounds present in high temperature tar are comparatively stable, having resulted from the decomposition of less stable bodies, and are only decomposable at the highest temperature of carbonisation. They decompose mainly by the elimination of hydrogen and the formation of compounds of increasing molecular complexity, and it would appear that the process ends finally with the formation of carbon itself. It has been suggested that, in view of the production of carbon in this way, the structure of the carbon molecule itself is far from simple. It is probable that the yield of gaseous therms obtainable from such a tar is very limited and can only be attained by sacrificing at considerable loss valuable constituents such as benzene and its homologues, thus rendering the tar of little value as an industrial commodity.

Before leaving the consideration of these experiments it should be noted from these results, and also from those shown in tables A and B, that the nature of the gas obtained during carbonisation is indicative of the nature of the reactions taking place in the retort. The greater the percentage of unsaturated hydrocarbons in the gas, the greater the quantity of primary tar which has been converted to high temperature tar and gas. On the other hand, a low proportion of these hydrocarbons may mean that the gas and tar have been subject to too long an exposure to heated surfaces.

The author is unable to draw a clearer picture of the process of tar cracking, but is sure that there is justification for supposing that the first products of high temperature

TABLE C.

CRACKING OF LOW TEMPERATURE TAR (10 GRAMMES).

Temperature of Heated Coke.	Duration of Experiment.	Volume of Gas (O_2 and N_2 Free).	P.Ct. by Weight of Recovered Liquid and Gaseous Products: Tar.†	Gas (calculated).	Total.	P.Ct. Composition of Gas (O_2 and N_2 Free): CO_2.	Unsaturated CnHm.	CO.	CH_4.‡	H_2.	Calorific Value (calculated) O_2 and N_2 Free Gas B.Th.Us. per C.Ft.	Gas Yield as P.Ct. of Therms in Original Tar.
	Hours.	c.c.	P.Ct.	P.Ct.	P.Ct.							
980° C.	2	8800	8.0	28.9	36.9	0.8	0.5	12.2	13.4	73.1	418	38.0
970° C.	2	9000	13.8	31.1	44.9	1.0	0.4	15.0	13.3	70.3	414	38.8
900° C. Expt. a ..	4	6000	20.4	27.5	47.9	1.8	1.0	12.6	31.1	53.5	545	33.8
„ b ..	2	5960	24.0	26.2	50.2	1.2	1.7	10.2	32.1	54.8	570	35.1
800° C. Expt. a ..	4	5725	27.4	27.5	54.9	1.6	1.8	12.3	33.7	50.6	581	34.2
„ b ..	2	4980	35.0	23.9	58.9	0.7	2.3	12.2	34.9	50.0	595	30.6
700° C. Expt. a ..	4	3965	36.2	21.6	57.8	1.2	2.6	12.3	43.1	40.8	664	27.2
„ b ..	2	2590	56.6	16.3	72.9	2.2	9.0	9.2	50.4	29.2	847	22.6
600° C. Expt. a ..	4	2470	49.2	13.6	62.8	1.4	8.1	8.2	49.9	32.4	830	21.2
„ b ..	2	1830	60.1	14.0	74.1	2.7	13.0	6.9	56.3	21.1	972	18.3

All experiments conducted in an atmosphere of nitrogen. *All gas measurements are made at 60° Fahr. and 30 in.*

†*Only approximate figures.* ‡ *CH_4 includes ethane and other saturated hydrocarbons.*

TABLE D.

CRACKING OF HIGH TEMPERATURE TAR (10 GRAMMES).

Temperature of Heated Coke.	Duration of Experiment.	Volume of Gas (O_2 and N_2 Free).	P.Ct. by Weight of Recovered Liquid and Gaseous Products: Tar.†	Gas (calculated).	Total.	P.Ct. Composition of Gas (O_2 and N_2 Free): CO_2.	Unsaturated CnHm.	CO.	CH_4.‡	H_2.	Calorific Value (calculated) O_2 and N_2 Free Gas B.Th.Us. per C.Ft.	Gas Yield as P.Ct. of Therms in Original Tar.
	Hours.	c.c.	P.Ct.	P.Ct.	P.Ct.							
1000° C. Expt. a ..	2	6520	4.2	17.3	21.5	1.3	0.0	8.7	10.2	79.8	384	25.8
„ b ..	2	5505	5.8	14.2	20.0	0.7	0.1	6.9	14.0	78.2	414	23.5
900° C. *Expt. a	2	4180	18.7	14.1	32.8	1.2	—	10.0	18.6	70.2	440	19.0
„ b ..	2	4360	28.0	12.6	40.6	1.0	—	11.6	9.6	77.8	381	17.1
800° C. Expt. a ..	4	3380	28.9	11.4	40.3	1.7	0.6	7.3	22.2	68.2	476	16.5
„ b ..	2	3080	28.3	10.1	38.4	2.1	0.7	6.0	21.2	70.0	470	14.9
„ c ..	2	2735	30.5	9.5	40.0	1.6	0.8	6.6	24.6	66.4	497	14.2
„ d ..	1	1325	51.0	5.8	56.8	2.8	1.8	8.0	30.7	56.7	556	7.6
700° C. *Expt. a ..	2	1500	34.2	5.4	39.6	2.6	—	5.0	29.4	63.0	508	7.9
„ b ..	2	1306	34.3	5.6	39.9	1.3	2.6	7.9	31.4	56.8	584	7.8
600° C. Expt. a ..	2	762	51.3	3.3	54.6	5.6	3.6	6.6	33.1	51.1	603	4.7
* „ b ..	2	460	54.0	2.0	56.0	2.2	—	4.1	43.7	50.0	606	2.9

All gas measurements are made at 60° Fahr. and 30 in.

**Experiments conducted in an atmosphere of coal gas, nitrogen being used in remaining experiments.* † *Only approximate figures.*

‡ *CH_4 includes ethane and other saturated hydrocarbons.*

carbonisation are similar to those of low temperature working, owing to the fact that the heating of coal is a gradual process, however rapid it may be. Thus, a study of the cracking of low temperature or primary tar gives some indication of the reactions likely to occur in the high temperature process. Yields in actual practice are, in fact, likely to be superior to those obtained by artificially cracking primary tar, as that tar itself may have suffered some degree of decomposition before its recovery, whereas the primary tar obtained during the actual working of the high temperature process is cracked, so to speak, *in statu nascendi.*

The most important conclusion to be drawn from this work is that the cracking of high temperature tar in large scale practice is likely to be an uneconomical process. The yields and quality of gas produced in the small scale experiments are poor, while the nature of the tar itself is degraded. When one commences to manufacture gas from high temperature tar by the maintenance of excessively high temperatures or by allowing too great an exposure of the products of distillation to high temperatures, it is then that the thermal energy of the coal begins ruthlessly to be wasted.

Having considered some of the chemical principles and the mechanism of tar cracking the question now arises whether it is economical to replace tar by gas. This question carries with it a few problems of accountancy.

The underlying principle of gas works accountancy is that all charges upon the undertaking and the revenues from all sales, including those from by-products, shall be expressed wholly as a debit or credit to the cost of gas manufacture; the revenue arising from the sale of coke, tar, ammonia, etc., is utilised solely for the purpose of reducing the selling price of gas. It is proper, of course, that this should be, as these subsidiary operations are carried out for the purpose of making and selling gas cheaply, but, in order to compute the relative values of a therm in gas, tar and coke, it is necessary to view the revenues from these products from a different perspective and to cause each to bear its own cost of raw material and working expenses. The revenue from tar, both in the case of an undertaking possessing its own tar-works and in those cases where tar is dehydrated or disposed of directly, is expressed as net revenue, after deducting all direct charges incurred in obtaining that revenue. The same applies to coke and this method of gas works accountancy causes tar and coke to be residuals in every sense of the word, for no contribution has been made by them for their share of the cost of the original coal, for expenses incurred in the retort-house, and, indeed, for the general overhead charges common to a gas undertaking. In order that the therms of the coal may be distributed in the most remunerative way, it is desirable that the accounts of the gas undertaking be analysed to show these points clearly. Although the author does not claim to be an authority on questions of accountancy, he has attempted to analyse the accounts of the three London Companies to show the contribution of *tar as tar* and *tar as gas* in reducing the selling price of gas. In this way it should be possible to obtain a conception of the relative values of the gas therm and tar therm. The selling price of gas was determined assuming

(1) That the tar has no value and is thrown away.
(2) That the tar is sold as tar and that its net revenue is deducted from the cost of gas manufacture (the usual practice).
(3) That the therms of the tar are converted with 100% efficiency into gas therms, allowance being made for the additional costs incurred in purification and distribution of the gas but not for the cost of conversion of tar to gas.

The figures obtained from the balance-sheets of the London Companies are as follows:—

Selling Price of Gas per Therm.

	1920.	1921.	1922.	1923
	d.	d.	d.	d.
Tar thrown away	11.8	12.7	11.3	9.6
Tar sold as tar .	10.6	12.2	10.9	8.8
Tar sold as gas .	10.1	10.9	9.7	8.2

It is thus seen that in the four years under consideration the contributions of *tar in the form of tar* to reducing the selling price of gas in the case of the London Companies are 1.2d., 0.5d., 0.4d., and 0.8d., per therm. Contrast these figures with the reductions in the selling price of gas which would have resulted had all the tar been converted into gas with 100% yield and without

incurring any process costs (except purification, distribution, etc.) —*viz.*, 1.7d., 1.8d., 1.6d., and 1.4d., per therm. On this basis, therefore, for the four years in question, tar in the form of gas would appear to have been respectively 1.4, 3.6, 4.0, and 1.7 times as valuable as it was in the form of tar.

It is difficult, however, to imagine that it is possible to convert all the high temperature tar into gas with 100% yield, but, provided the process of gasification of a part of the tar can be carried out with a high degree of efficiency without decreasing the market value of the remaining tar, and provided no additional retort-house costs are incurred, particularly in regard to stopped pipes, then the process of gasification is an economical one and should be practised. The degree to which tar gasification should be practised, however, is entirely dependent upon market conditions, and from the figures given above, it would appear that in the years 1920 and 1923 it would not have been a paying proposition to gasify tar to any considerable extent. Unfortunately, to determine the wisdom or otherwise of gasifying tar under any conditions of market price, calculation and some experimental determinations are required which cannot conveniently be practised universally. For general purposes, however, it may be stated that, year in and year out, it is economically sound to gasify as much tar as possible, as long as troubles are not being experienced with stopped pipes in the retort-house and the free carbon content of the residual tar does not exceed 15%. (This figure is given as one above which serious deterioration and waste of secondary tar may result.)

It is not proposed to deal with the characteristics of high temperature tar, but it may be of interest to note in passing that the free carbon content of the tar is not only an indication of the amount of secondary decomposition that has taken place, but is also an indication of the ease with which the tar may be distilled at the tar works. A tar possessing a high free carbon content has the power to emulsify with water and it becomes increasingly difficult to separate the water by distillation as the percentage of free carbon increases.

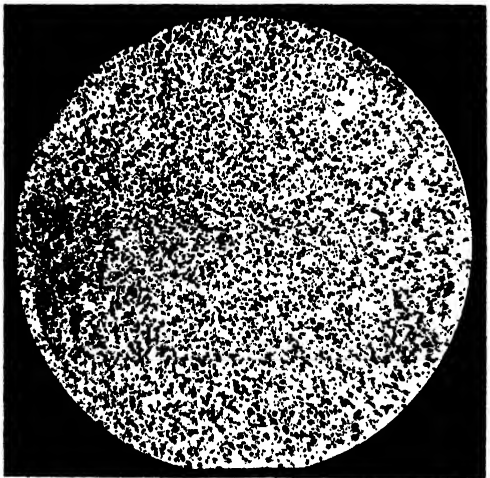


FIG. 25.

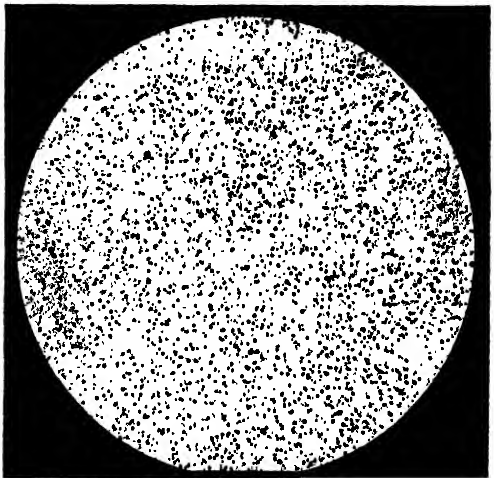


FIG. 26.

A ready method of observing the free carbon content of tar is to produce a microscopic slide smudge. Fig. 25 represents a smudge obtained from horizontal retort tar, and Fig. 26 one from vertical retort tar.

It is now proposed to attempt to determine the practical applications of the experimental results and theoretical considerations submitted in this lecture. Large scale experience, as well as the experimental work presented, demonstrates that the gas manufacturer who wishes to obtain a maximum gaseous thermal yield must carbonise coal as rapidly as possible. If two retorts of equal length and volume are taken and in one 6 cwt. of coal are carbonised up to 1000°C. in 6 hours, and in the other 10 cwt. are carbonised up to the same temperature in 10 hours, then the rate of heating will be greater in the case of the small charge, and it is a recognised fact that

the old method of 6 hour work and 6 cwt. charges gives better gaseous therm yields. This method of working, however, carries with it so many disabilities in the form of stopped pipes (the costs of which cannot be computed in terms of therms per ton), that the quest for gaseous therms must of necessity give way when such troubles become acute. By increasing the weight of the charge and the period of carbonisation, the tendency is to conserve the tar, but there must come a stage when the tar yield is so high and the gas yield so low, that means have to be taken for promoting the cracking process. Moreover, considerable difficulty is experienced in preventing the very fluid tar from refluxing in the ascension pipe and the main disability of distilling 12 cwt. charges in 12 hours has been the loss of tar at the mouthpiece, though means have now been adopted for obviating this loss. To-day the tendency in horizontal retort working is to approach rapid carbonisation by raising the temperatures of the setting, so that a maximum charge of coal may be carbonised in a smaller number of hours than the weight of the charge in cwts.—*i.e.*, 10 cwt. in 8 hours—13 cwt. in 11 hours, etc. This is the method now being adopted to obtain the most rapid carbonisation in horizontal retorts without incurring the difficulties of stopped pipes, and it is the way in which high gaseous therm yields are obtained, although the tar yield naturally suffers slightly. There will, however, come a time when these modified weights and periods of carbonisation will tend to produce the disadvantageous conditions of the light charge; the author does not know precisely where the transition point lies. With the manufacture of fire-clay material of greater and greater fire-resisting and heat-transmitting properties, too great a degree of drasticity of distillation will tend to be reached, with the result that the limit of efficient working will be overstepped and retort-house disturbances will be incurred. Further, it has been shown that the cracking of tar as it is produced, or at the very instant after its production, differs appreciably from the cracking of secondary tar in a heated chamber. It follows from this that the cracking of tar in the coal substance is one thing, whereas the cracking of tar in the heated free space of a half-filled retort is an entirely different matter. The tendency of modern carbonising practice in horizontal retorts is to reduce the free space to an absolute minimum, and the author is certain that this is advantageous to the distillation process. What is required, however, is greater rate of heat transmission within the coal substance and this subject will be dealt with in the next lecture.

In conclusion, the author has demonstrated in one set of experiments the value of rapidly heating the charge. Rapid heating means the maintenance of high temperatures at the retort walls. The second set has shown the folly of attempting to gasify secondary tar, and at high temperatures, even primary tar, while the experiments have indicated also the necessity for preventing the products of distillation from coming into contact with highly heated surfaces. Good carbonisation is a fight between these two factors, and it is impossible to recommend any hard and fast rules of procedure to be adopted in the gas industry. Each gas undertaking is almost a law unto itself, governed by its existing plant, its geographical position, its market for by-products, and the requirements of its consumers. It has not been generally realised in the past that the conditions of carbonisation can be readily modified in order to give the required distribution of therms, and to-day it is not a difficult matter for a chemist to determine the conditions likely to be most remunerative and satisfactory with the plant at the disposal of the engineer.

Some of the hypotheses put forward for consideration may one of these days be found to be hopelessly unsound, but even if this be the case, the main point of this lecture will still hold—*viz.*, the inadequacy of thinking in terms of gaseous therms alone and the necessity for taking into consideration the total volatile therms in the form of both tar and gas.

The author takes the opportunity of acknowledging the help afforded by Mr. E. Anson Dyer, who has prepared the film used for demonstrating some typical chemical changes. The large amount of work entailed has been undertaken by him in the belief that this method of depicting chemical reactions will play an important rôle in the teaching of chemistry in the future.

LA VIE INDUSTRIELLE EN FRANCE.

Un Nouvel Appareil pour le Tracé Automatique de la Route sur la Carte à Bord des Navires.

La Marine française a expérimenté dernièrement un nouvel appareil traceur de route, inventé par le Lieutenant de vaisseau Baule. Cet appareil intègre tous les mouvements du navire et les trace sur la carte à mesure de la marche du bâtiment. Il décompose l'enregistrement du cap et de la vitesse en mouvements distincts, à une ou deux secondes d'intervalle; il trace des éléments rectilignes très petits, qui pratiquement, se confondent avec la route exacte.

Dans cet appareil, la carte est tendue sur un cadre au-dessous duquel est disposé un mécanisme électro-mécanique. Sur la carte même se trouve une bille en acier enduite d'encre, qui se déplace en laissant une trace sur la carte, sous l'action d'un électro-aimant faisant partie du mécanisme. Ce mécanisme se compose principalement d'un chariot portant l'aimant, capable de se déplacer le long d'un bras rectiligne articulé à un côté du cadre; ce chariot repose d'autre part sur un plateau qui peut recevoir un mouvement rectiligne alternatif, et un mouvement de rotation. Le mouvement de rotation est asservi avec celui du compas du navire; il traduit donc sur la carte les changements de direction.

Le tracé des secteurs représentant les parcours pendant chaque unité de temps est effectué sous l'influence du fonctionnement d'un loch à bulles. Dans cet appareil, un réservoir d'air comprimé à faible pression laisse échapper par une soupape une certaine quantité d'air dans un tube parcouru par un courant d'eau résultant de la marche du navire. Les bulles d'air passent successivement sous un plot électrique disposé à l'arrière du tube. Chaque bulle qui passe interrompt le courant électrique d'une pile qui passe par ce plot, ce qui commande en même temps l'envoi de la bulle suivante. La succession des bulles peut ainsi être employée à envoyer dans un circuit électrique des impulsions en nombre proportionnel à la vitesse, toutes les fois, par exemple que le navire a parcouru 1/200ème de mille. Ces impulsions sont traduites sur le traceur de route, au moyen d'un mécanisme trop compliqué pour être décrit ici, par un déplacement du chariot, qui trace sur la carte un secteur de 1/200ème de mille. Ensuite, si la direction a changé, le plateau tourne d'une manière correspondante, puis s'immobilise pour le tracé du secteur suivant, et ainsi de suite.

Avec cet appareil, le rôle de l'officier de quart se borne à la vérification de l'échelle suivant la latitude. Le traceur a encore l'avantage de se prêter facilement à la répétition du tracé en un point quelconque du navire: dans le bureau ou le blockhaus du commandant, par exemple. Un appareil simplifié, relié à l'appareil principal par des connexions électriques suffit à cette répétition.

Des expériences faites sur des trajets compliqués ont montré l'exactitude du fonctionnement de l'appareil.

L'Usine Électrique Marémotrice de l'Aber-Wrach, près de Brest (Finistère).

Depuis plusieurs années, les ingénieurs français s'occupent d'utiliser la force des marées pour la production d'électricité, dans des groupes turbo-alternateurs actionnés par le flux et le reflux de la mer. Le principe est très simple, mais l'application l'est beaucoup moins, car le fonctionnement de l'usine est forcément intermittent. Plusieurs combinaisons ont été proposées pour atténuer l'irrégularité de la puissance, et l'une des plus intéressantes est celle de l'Ingénieur belge Defour. Ce n'est cependant pas ce système qui a été adopté pour la première installation marémotrice qui vient d'être décidée en France. On s'est arrêté à une conception très simple de l'usine marémotrice, en demandant à une seconde usine ordinaire de régulariser son débit en fournissant à chaque moment la puissance supplémentaire au réseau.

L'Etat français ayant décidé de faire construire une première usine marémotrice, pour mettre au point l'étude pratique de ce problème, a choisi la solution de deux usines conjuguées, situées à 25 Km. au nord de Brest, elles alimentent ce port de guerre, qui a également une certaine importance industrielle.

L'usine marémotrice de 6,000 h.p. sera installée sur l'estuaire de l'Aber-Vrach. Elle sera conjuguée avec une usine hydro-électrique d'eau douce qui utilisera la force de la rivière le Diouris, affluent de l'Aber-Vrach; les eaux de ce cours d'eau seront retenues par un barrage de 30 mètres de hauteur. Une ligne à haute tension reliera les deux usines avec Brest.

Une loi de Décembre, 1923, avait fixé la participation financière de l'Etat à cette entreprise, et deux décrets d'Août, 1924, viennent de concéder l'exploitation des deux usines et de la ligne à haute tension à la "Société financière pour l'Industrie." Ainsi se trouve close la période de préparation, et celle de réalisation vient de s'ouvrir. On peut ainsi espérer voir bientôt construite la première usine marémotrice française.

L'Electrification des Chemins de Fer de la Banlieue de Paris.

Les Chemins de fer de l'Etat exploitent à l'ouest de Paris un important réseau de banlieue qui comporte actuellement 800 kilom. (500 miles) de voies simples et dessert la partie la plus peuplée des environs de Paris. Il possède dans Paris 3 grandes gares: celles de Montparnasse et des Invalides sur la rive gauche, et celle de Saint-Lazare sur la rive droite de la Seine. Cette dernière assure la plus grande partie du trafic: sur 70 millions de voyageurs amenés par an avant la guerre par le réseau de l'Etat, 60 millions arrivaient par la gare Saint-Lazare. Le nombre des voyageurs quittant la gare pendant l'heure la plus chargée (de 18 h 30 à 19 h 30) était de 13,000 en 1910, 18,000 en 1920, et dépasse actuellement 23,000.

Pour répondre à un tel accroissement de trafic, on a décidé d'électrifier les lignes de petite banlieue.

Les deux premières lignes électriques, les plus chargées, viennent d'être mises en service, ce sont celles de Paris à Bois-Colombes, et à Bécon-les-Bruyères.

La traction est assurée au moyen d'automotrices à courant continu à 650 volts. Le courant est produit dans deux usines principales appartenant au chemin de fer, l'une à Bezons, l'autre aux Moulineaux, de 20,000 kilowatts chacune, cette puissance devant être doublée plus tard. Le courant est produit sous forme triphasée à 15.000 volts, et il est transformé en courant continu dans une quinzaine de sous-stations réparties dans tout le réseau.

Les automotrices et les remorques sont de construction analogue. Elles sont entièrement métalliques, établies sous la forme d'une "caisse-poutre" de grande résistance. L'automotrice est portée par deux bogies moteurs, chaque bogie étant actionnée par deux moteurs de 165 h.p.; la puissance totale est donc de 660 h.p. Les trains sont formés d'éléments de traction indécomposables, constitués par une automotrice et une remorque. Suivant l'affluence des voyageurs, les trains sont constitués de 1 à 4 éléments semblables, et la puissance est ainsi toujours proportionnelle à la charge. Pour faciliter la formation de ces trains, les extrémités de chaque élément sont munis d'un attelage automatique. La commande peut se faire, soit de la cabine principale de l'automotrice, soit d'une petite cabine auxiliaire, à l'extrémité de la remorque, pour la marche en sens inverse.

L'équipement est du type Sprague multiple Unit Control; il est constitué de façon à pouvoir fonctionner indifféremment sous 650 volts ou sous 1,500 volts, pour le cas où l'on adopterait plus tard cette dernière tension; l'appareil de manœuvre principal, du type électropneumatique, est placé dans la cabine du wattman, de sorte que toutes ses parties sont facilement accessibles.

Un élément de traction, formé d'une automotrice et d'une remorque, peut transporter normalement environ 370 voyageurs, dont 70 de première classe, de sorte qu'un train moyen de 3 éléments en transporte plus de 1,000. Aux heures d'affluence, le matin et le soir, les trains sur les deux lignes électrifiées partent à intervalles de 15 minutes, de sorte que les gares intermédiaires communes aux 2 lignes sont desservies à intervalles de 7½ minutes.

La traction électrique sera mise en service sur une seconde zone l'année prochaine, et l'ensemble du réseau de banlieue sera électrifié en 1927.

OBITUARY.

EDWARD TANCRED AGIUS.—By the death of Mr. E. T. Agius, from heart failure, on September 21st, at his residence, No. 3, Belsize Grove, Hampstead, the Society loses a supporter of long standing, he having been elected a member in 1896. Mr. Agius, who had reached his seventy-sixth year, was senior member and managing director of Messrs. E. T. Agius, Ltd., of 10 and 11, Lime Street, E.C., a firm established over half a century ago and possessing branches at Cardiff, Newcastle-on-Tyne, Glasgow, Liverpool, Swansea, Hull, Southampton, Genoa, Malta and Alexandria.

The oldest active member of the Baltic Shipping Exchange, he was also a member of the London Chamber of Commerce and of many other chambers of commerce; Commissioner for Malta at the British Empire Exhibition; and since the autumn of 1923 he has represented the interests of Malta on the Dominions and Colonies Section Committee of the Royal Society of Arts. He was well known for his generous assistance to deserving charities.

VICTORIA AND ALBERT MUSEUM.

The Victoria and Albert Museum has recently acquired, through the generous gift of Mrs. Gabrielle Enthoven, her Collection of Play-Bills and Theatrical Programmes, representing the active enthusiasm of many years. The Collection, which is by far the largest in existence, contains many prints, autographs and architectural drawings as well as play-bills, and comprises over 50,000 items ranging from the beginning of the 18th century until modern times. The earliest bill is for a performance of "Comus," at Covent Garden in 1730, and the Collection contains almost complete sets of the nightly play-bills, beginning in the 18th century, of theatres such as Drury Lane, Covent Garden, the Haymarket, etc.

The play-bills have already been of service in the identification of drawings of costume and scenery, and many of the bills have considerable literary and dramatic interest. The Collection includes the announcement of the first appearance on the London stage of "a young lady" who was afterwards to be known as Mrs. Siddons, and the bill for the first performance of "The School for Scandal." There are 240 bills referring to Garrick, and almost complete sets for Peg Woffington, Kean and Macready. Mrs. Enthoven's object, however, has not been to collect individual curiosities but to make her collection as complete as possible in order that it may serve as reliable material for the art of the theatre and for theatrical history, which, in the past, has been notoriously inaccurate from the very real difficulty of finding trustworthy records.

The play-bills are to be stored in the Department of Engraving, Illustration and Design, which, it will be remembered, was responsible for the International Theatre Exhibition held at the Museum in 1922. When the work of cataloguing and indexing the collection has been completed the new material will be available in the Students' Room of the Department, which contains a steadily growing collection of designs for theatrical scenery, costume, and architecture.

The main portion of the Enthoven Collection up to the year 1870 has already been placed in the

Museum, and the work of continuing the collection and of filling up gaps, particularly in connexion with modern plays, is being carried on with Mrs. Enthoven's valuable help. Every effort is being made to render this collection as complete and authoritative as possible; and Mrs. Enthoven and the Museum Authorities will welcome gifts of any play-bills or programmes which are missing from the collection.

DUMFRIES AND GALLOWAY BACON.

Dumfries-shire and Galloway have long been celebrated in Scotland for their dairy farms, and there are many well-known herds of Ayrshire and other breeds of cattle in both localities. Naturally, this gives rise to pig-breeding; as separated milk from butter-making, and whey from cheese-making, form excellent foods for pigs.

Generally speaking, the breeds of pigs which are mostly favoured in the South-West of Scotland are three in number, *i.e.*, the Large Black, Large White Yorkshire, and Middle White Yorkshire. These pure breeds and their various crosses are largely favoured by bacon-curers, and there has been much development of pig-breeding in this part of Scotland during recent years, the demands of the bacon-curers having increased very greatly.

Bacon-curing is the natural corollary of pig-breeding, and there is plenty of room in Scotland for development in this particular industry, as the imports of bacon and pig products from overseas are enormous.

The value of such imports into Great Britain at the present time is around 55 million pounds per annum, and it is only reasonable to suppose that a large proportion of this business could be retained at home, if pig-breeding were more developed throughout the country. The home article, also, always commands the highest price.

There have been several new bacon factories organised in Scotland during recent years. The latest of these is at Dumfries, where some very handsome buildings at Terregles, near the town, have been acquired, and are being converted into a modern bacon factory from the designs of Mr. Loudon MacQueen Douglas, F.R.S.E., of Edinburgh. The factory has been equipped, to begin with, to handle about 250 pigs a week; and the lay-out has been arranged so that the capacity of the factory can be doubled with very little trouble.

The work to be carried on will be the production of Scottish rolls, hams, and Wiltshire bacon, and it is confidently anticipated that there will be a large demand for the Scottish-cured Wiltshire sides.

The factory will embrace all the different departments which go to make up the general success of such an establishment, and the most modern machinery and appliances are being installed in the sausage department, ham cooking, and general cooking room, lard department, and bakery and by-products department. It is very little use indeed to try to make a bacon factory a success without specialising in these auxiliary departments, and it is a curious fact that there seems to be unlimited demand for these secondary products, more especially when they are prepared by an expert, such as has been appointed to the Dumfries factory.

It is hoped that the factory will be in a position to receive pigs in large numbers shortly, and that the products will soon become familiar in Scotland and elsewhere.

CEMENT MANUFACTURE IN THE EMPIRE.

The manifold uses of cement and especially its employment for the manufacture of concrete, which is so largely used at the present day in place of brick and stone for structural purposes, render it of no little importance that all countries should be able to obtain cement for local use at a reasonable cost. In many overseas countries, particularly those remote from the present centres of production, the use of cement is greatly restricted owing to the heavy cost of shipment and the consequent high price of imported supplies.

Portland cement is already being made in large quantities in several overseas countries of the Empire, such as Canada, Union of South Africa, Australia, New Zealand and India, whilst operations on a smaller scale are being carried on in the Sudan, Rhodesia and Malaya. It seems probable that the raw products required for cement manufacture exist in nearly all parts of the Empire, but hitherto little information has been available regarding the possibilities of establishing a cement industry in most of the Crown Colonies and Protectorates. Considerable attention has been devoted to this question in recent years by the Imperial Institute, where a fully equipped cement-testing laboratory has been installed, and the first part of an interesting article on the subject is published in the current issue of the quarterly "Bulletin of the Imperial Institute." An outline is given of the manufacture and properties of different kinds of cement, special attention being devoted to the characteristics required in the raw materials used for the several classes of cement now employed in building. This is followed by particulars relating to the opportunities of cement manufacture in the Crown Colonies and Protectorates; under each country is given an account of the deposits so far known, results of tests carried out at the Imperial Institute, and a discussion of the prospects of establishing a cement-making industry. In the first part, now published, British West Africa is dealt with. It is shown that cement materials occur in Nigeria which are worth further investigation and technical trial, particularly in view of the existence in the country of deposits of coal and lignite which could be used as fuel. Suitable limestones appear to occur also in the Gold Coast, but there seems to be little chance of finding in Sierra Leone materials in sufficient quantity for cement manufacture.

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PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

A STUDY OF THE DESTRUCTIVE DISTILLATION OF COAL.

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Lecture III.—*Delivered March 10th*, 1924.

In the previous lecture it was demonstrated that rapid carbonisation is essential if the best yields of gaseous therms are to be obtained. It will be remembered that this was considered to be due to the fact that with rapid carbonisation the average temperatures maintained throughout the coal charge are higher than in the case of slow carbonisation and that in consequence the tar is subjected to a higher degree of cracking, with the result that gas is produced at the expense of tar. It was decided that this practice of converting tar into gas was generally the most economical one to adopt in the gas industry, provided that the cracking process was effected without decreasing the market value of the resulting tar and causing retort-house troubles in the form of stopped pipes. The question, therefore, is how to modify the carbonising process in order to increase the rate of heat transmission not only through the retort walls, but also through the charge itself. The use of retorts manufactured of a material which is a better conductor of heat than the fire-clay employed to-day will solve the first of these problems, and, in America, carborundum is coming to the fore in this connexion. The rate of heat transference through the coal charge, however, will still be slow, no matter how rapid it may be through the retort walls, and the more important problem which is presented for solution is that of increasing the conductivity of the coal.

Before passing on to a consideration of the question of treating coal prior to carbonisation in order to increase the rate of heat transmission, the author wishes to describe the physical changes which are believed to take place when ordinary coal is undergoing carbonisation. In a well-filled horizontal retort, with some 3in. or 4in. space above the top of the charge, it is probable that the periphery of the charge, which is in direct contact with the walls of the retort, very rapidly attains a high temperature. The rate of heat transmission to the centre of the charge would, if the material were not undergoing constant physical change, be very rapid during the first few hours, but would gradually decrease as the temperature of the charge approximated that of the retort wall. The physical condition of the coal, however, does change during the period of carbonisation, and particularly during the first few hours, and it is these changes which are deemed largely responsible for the low heat conductivity of the charge. It is known that certain resinous constituents of the coal—the so-called gamma compounds—melt readily, and it is probable that the fusion of these constituents is responsible for the cementing together of the charge. It is conceived that the outer crust of the charge is very rapidly carbonised and cemented into coke and that this may take place even while, in the centre of the charge, there exist pieces of coal which still retain their identity although perhaps they may have become slightly plastic on the surface. As the temperature of the mass gradually increases there appears to be produced a plastic layer which forms a semi-liquid wall enclosing coal which up to this point has remained practically unchanged. As this coal undergoes decomposition, some of the gaseous products force their way through the plastic layer, which in consequence becomes much distended by the bubbles of gas. Meanwhile the semi-liquid layer itself is undergoing

decomposition, the gases evolved adding to the effect of those from the decomposing coal within. As decomposition proceeds, the layer gradually loses its plastic nature and ultimately hardens, giving the cellular structure typical of an ordinary gas coke. It is the cellular nature of the carbonised mass which is the cause of the low heat conductivity of the material and it is thus indirectly the plastic layer which impedes the rate at which heat is transmitted into the charge. It is imagined that the gases evolved during the whole of this process fight their way to the wall of the retort either through the plastic layer or through the cellular coke already produced, and if evolved at the side or bottom of the retort, travel between the charge and the retort wall until they reach the space above the charge. An untold hubbub must take place as the plastic layer finds its way towards the centre of the charge and is there gradually heated to the decomposition point. Whereas the volatile matter evolved during the early stages of carbonisation had to run the gauntlet of the heated outer layers only, now every bubble of gas produced must fight its way through the whole mass—through tar and other semi-liquid products—until it finds a means of exit through the innumerable channels of the partly and fully cokified portions. Each step it takes brings it into a hotter zone and the molecule which, as may be imagined, started from the centre of the charge with a wonderful degree of complexity, is submitted to such disruptive influences that by the time it finds its way through the coke it has been reduced to a comparatively simple form. Even then it still has to run the gauntlet of the space above the top of the charge. In all these reactions of decomposition a certain time of contact is necessary and the final form taken by this molecule will depend largely upon whether it be withdrawn from the retort before sufficient time contact has been given to break it down completely. A knowledge of chemistry does not help very much in the interpretation of this picture—in fact it rather tends to complicate matters—for it allows one to appreciate better not only the complexity of the reactions, but also the almost limitless range of reactions that may take place.

This picture of the physical changes which coal is supposed to undergo on heating has indicated that indirectly it is the plastic layer which prevents heat being rapidly conducted through the coal charge—a conclusion which has been reached by a number of investigators. The problem of increasing the heat transmission of the coal substance itself will be solved, therefore, by adopting suitable means for preventing the formation of the plastic layer. The absence of the plastic layer and the avoidance of large cells will allow rapid penetration of heat through the charge, and in consequence one would naturally expect, from the conclusions arrived at in the previous lecture, that an increased yield, not only of gaseous therms, but also of total volatile therms, will be realised. It is known that expansion of the charge during carbonisation may be avoided, or at least very materially reduced, by admixing with the coal to be carbonised an inert absorbent material such as coke or coke-breeze. This material, if intimately mixed, will prevent the formation of a plastic layer by absorbing the tar-like matter formed and by providing an infinite number of small pores and channels through which gases may escape. Moreover, the tendency of the material to expand during carbonisation will be reduced, as the large cells which originate from the plastic layer will no longer be formed. It is these large cells which constitute such a great impediment to heat transmission, and with the particles of coal and inert material lying in close proximity during the whole carbonising period, a small-celled structure will be produced, with the result that the rate of heat transmission will be considerably augmented.

It can be demonstrated by experiment that, by admixing coke with coal and briquetting the mixture without a binder, the rate of gas evolution is materially increased. For this purpose equal weights of the same coal, one sample of which is briquetted with 25% of coke, are heated in silica bulbs in a furnace, the temperature of which is from 900° to 1000°C. The rate of gas evolution is found to be materially greater in the case of the briquetted mixture, showing that the effect of the inert absorbent material in the coal mass is to increase the rate of heat transmission. Such an experiment, although on an exceedingly small scale, demonstrates clearly the difference in the respective rates of carbonisation of coal alone and of coal briquetted with coke. The results of some experiments, carried out on a somewhat larger scale, using quantities of the order of a retort charge

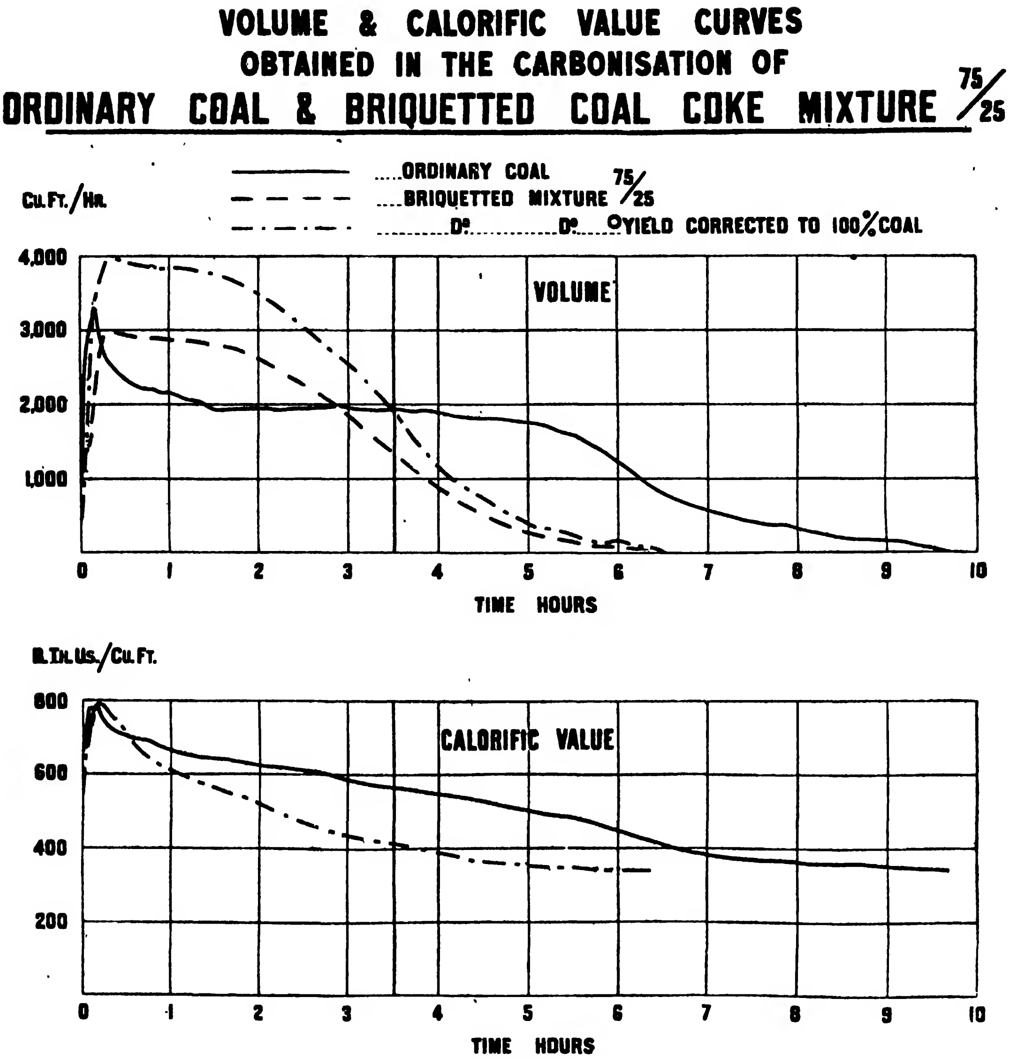

FIG. 27.

are, however, of still greater interest. In Fig. 27 are seen the volume and calorific value curves plotted from the results obtained in the carbonisation of a briquetted 75/25 mixture of coal and coke; the curves are compared with those obtained as the result of carbonising a similar weight of coal alone under similar conditions. The results relating to the briquetted mixture have also been corrected to 100% coal, and the curves obtained in this case show how the rate of distilling the coal is affected by briquetting with coke.

These curves indicate very clearly that the nature of the carbonisation process is entirely changed when a briquetted coal-coke mixture is used instead of ordinary coal. The carbonising process has been accelerated to such an extent that the whole of the gas has been expelled from the briquettes in 6½ hours, as compared with 9½ hours in the case of untreated coal. The difference between these two periods is 31½%, and if allowance be made for the fact that inert material is mixed with the coal to the extent of 25% it will be found that the throughput of actual coal will be increased slightly when 75/25 briquettes are carbonised. Striking though the diagrammatic curve may be, it is here that the thermal models employed in the first lecture show so admirably the difference in the rate of carbonisation produced by the admixture of an inert material with the coal. Fig. 28

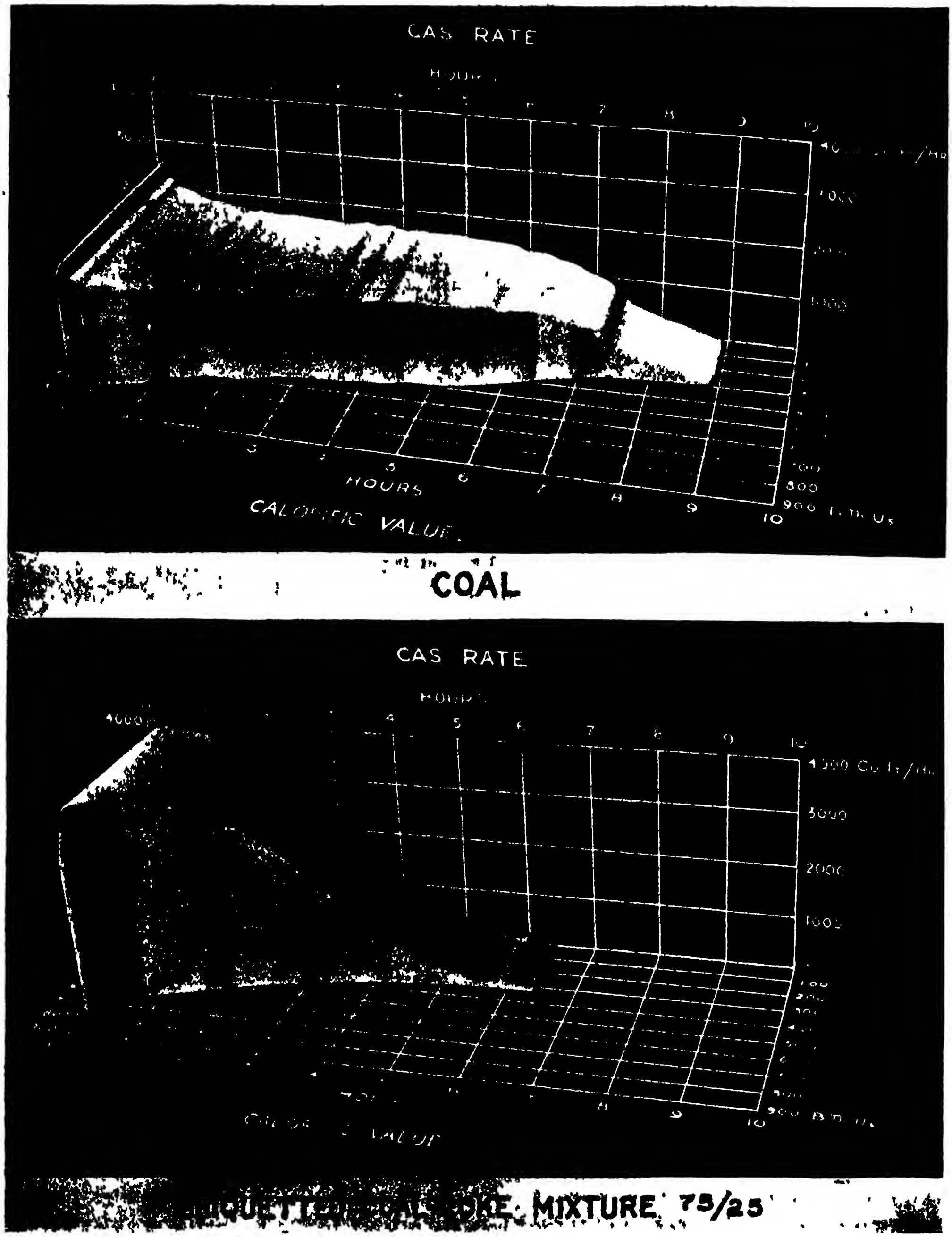

FIG. 28.

shows the thermal models obtained from carbonisations of ordinary coal and of a briquetted coal-coke mixture. The principle of these models was described in Lecture I.

In the first lecture it was also demonstrated how striking was the difference between the amounts of useful work effected in the retort during the middle ten minute periods of the first and last hours of the carbonising period. Striking though this is, the difference is greatly accentuated in the case of the carbonisation of briquetted coal-coke mixtures. Fig. 29 shows three sections taken from the thermal model obtained from the 10-hour carbonisation of ordinary coal and two sections taken from the

10-MINUTE SECTIONS TAKEN FROM THERMAL MODELS.

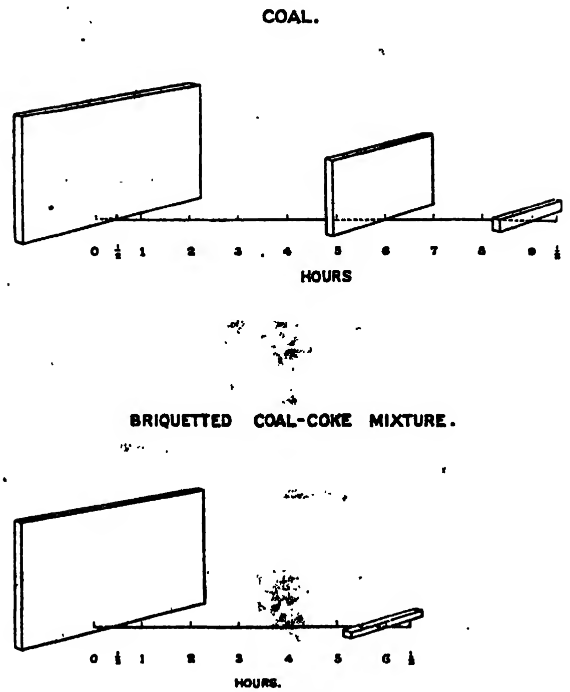

Fig. 29.

thermal model relating to the carbonisation of an equal weight of a 75/25 coal-coke mixture. The most outstanding observation to be made is that when the briquetted material has lost practically all its volatile matter a large amount of work is still being effected in the case of the slower carbonisation of ordinary coal.

It is quite evident, therefore, that the admixture of an inert material with coal

TABLE E.

CARBONISATION OF COAL AT VARYING RATES (100 GRAMMES TYPICAL DURHAM COAL, BRIQUETTED).

Time taken to reach 1000° C.		Distribution of Heat Units in Products. Therms per Ton of Original Coal.						Process Yield of Therms.	
Hours.	Mins.	Coke.	Tar.	Gas.*	Carbon and Pitch.	Total Volatile Therms.	Total Non-Volatile Therms.	Per Ton of Coal.	P.Ct.
—	18	195	21.6	78.1	3.4	99.7	198.4	298.1	92.0
—	40	197	21.6	76.3	4.9	97.9	201.9	299.8	92.6
1	40	200	29.1	67.3	2.3	96.4	202.3	298.7	92.3
1	40	200.5	28.3	67.2	3.5	95.5	204.0	299.5	92.5
3	15	203	24.6	70.2	1.3	94.8	204.3	299.1	92.4
13	0	206	19.8	70.0	4.4	89.8	210.4	300.2	92.7
13	0	207	18.1	70.3	3.9	88.4	210.9	299.3	92.4

All gas measurements are made at 60° Fahr. and 30 in.

* *A correction of + 1.5 therms per ton for residual gas in apparatus has been applied.*

increases the rate of gas evolution and the next question that arises is whether this enhanced rate of gas evolution is accompanied by the superior thermal yield of gas which is to be expected from the results of the laboratory investigation already described in Lecture II. These results are reproduced in an abbreviated form in Table E.

Carbonising trials with briquetted coal-coke mixtures have been carried out in an experimental plant, but up to the present we have failed to operate the setting in such a way as to obtain through the retort walls the quantity of heat required to effect the degree of tar cracking necessary to give the enhanced thermal yield of gas. What has been done, however, is to obtain the increased volatile therm yields such as resulted from the laboratory experiments. Some typical results obtained are given in Table F:—

TABLE F.

CARBONISING RESULTS FROM DURHAM COAL AND BRIQUETTED MIXTURES OF SAME COAL AND COKE (75/25).

———	Ordinary Coal.	Briquetted Mixture.	
		A.	B.
Yield of gaseous therms per ton of coal ..	74.7	68.2	71.1
Yield of tar therms per ton of coal	16.1	31.0	27.5
Total yield of volatile therms per ton of coal	90.8	99.2	98.6

In the A series of experimental trials, involving altogether 22 tons of briquettes, the combustion chamber temperature was maintained some 50°C. lower than in the B series, where a total of 12 tons of briquettes was carbonised. With the increased combustion chamber temperature a higher gaseous thermal yield has been obtained at the expense of tar, but even under these conditions the process has been operated only as a tar conserving one. Still, notwithstanding the 25% of inert material introduced into the retort, a small increase is to be observed in the throughput of true coal.

It is probably unnecessary to point out that the carbonisation of this briquetted material raises manifold technical problems which are being dealt with as rapidly as time permits. The presentation of these results, however, will be sufficient to demonstrate that an entirely new field is open for the production of a more economic distribution of the therms of the original coal. As many as 8 to 9 additional volatile therms, which are several times more valuable than non-volatile therms, have been obtained from the particular coal under test. These additional volatile therms are, as indicated in Lecture II, obtained at the expense of coke, and it will subsequently be necessary to account for them theoretically. It will be appreciated that the distribution of the thermal energy of coal in this new way will constitute an important contribution to the coal conservation problem. The tar obtained in these experiments possesses a somewhat higher free carbon content than that produced under similar conditions from ordinary coal. The nature of the coke produced, however, is an outstanding feature of this process. It possesses very distinct advantages over the solid fuel produced from the rapid carbonisation of ordinary coal.

(Here an experimental carbonisation of coal and a coal-coke mixture was carried out in silica test tubes and it was demonstrated that the friable product obtained from ordinary coal under the conditions of the experiment was replaced by a stabilised and dense material in the case of the briquetted mixture.

Demonstrations were also made which might be termed "experiments in parenthesis" illustrating the remarkable modifying action of inert material on the carbonisation of sugar and the burning of mercuric thiocyanate, the ash of which results in the so-called "Pharaoh's serpents.")

The question of carbonising briquetted mixtures has here been presented from the point of view of obtaining the maximum yield of volatile therms; other investigators

have recommended the addition of inert matter to the coal in order to obtain a resulting solid fuel of high density and with a high degree of combustibility. That this solid fuel is indeed superior to coke has been admirably shown by E. C. Evans. It possesses a greater heat conductivity than ordinary coke, owing to the fact that the the absence of the plastic layer has prevented expansion of the coal, with the result that a small-celled structure is produced. In consequence, combustion proceeds with greater velocity, while the powdered ash, instead of containing as much as 10 to 20% of combustible matter (as is often the case with coke ash), is practically free from carbon. Many investigators are engaged in a study of this fuel and for several years the author

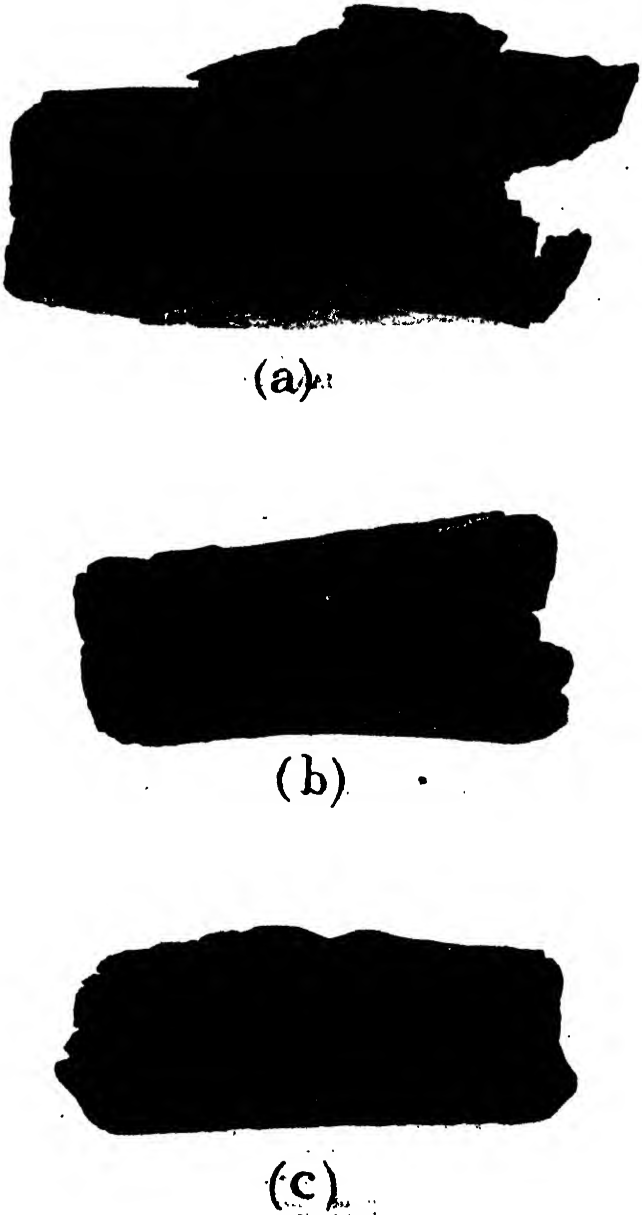

Fig. 30.

has been working upon this question — recently in collaboration with E. R. Sutcliffe and E. C. Evans. It is to their publications and to those of Roberts and others that reference should be made for more detailed information regarding the virtues of this fuel.

It has been demonstrated that the process of carbonisation of a briquetted coal-coke mixture possesses distinct advantages, in that it results not only in an enhanced yield of volatile therms, but also in a very superior solid fuel. Before discussing the advantages and disadvantages of such a process from the gas manufacturer's point of view, it is proposed to deal with the following question :—viz., what is the origin of the additional volatile therms produced in briquette carbonisation ?

It will be remembered that originally it was decided to admix an inert material with coal in order to break up the plastic layer which prevented heat being readily transmitted through the mass. In the first place it is essential to admix the correct proportion of coke, as will be seen from Fig. 30, which shows sections of briquetted fuel from (a) 100% coal, (b) 85/15 coal-coke mixture, (c) 75/25 coal-coke mixture. It will be observed that while the formation of the plastic layer is reduced in the case of 85/15 coal-coke mixture, it is almost entirely avoided when as much as 25% of coke is admixed with the coal. That there is practically no plastic layer formed when the right proportion of coke is used in the briquette may be proved by the fact that if one arrests the distillation process at any time after the third hour the volatile matter remaining is evenly distributed throughout the briquette. The importance of this observation in supporting the contention that the plastic layer is avoided in briquette carbonisation is apparent and it contributes very materially in making clear the new carbonising picture.

Fig. 31 shows sections of ordinary coke and of that obtained from the carbonisation of a 75/25 coal-coke mixture. From these sections there may be seen on the one hand the particular cellular structure so typical of ordinary coke—the result of the ravages of the plastic layer—and on the other hand the very dense small-celled coke which is produced when the formation of the plastic layer is avoided. Now the larger cells of the normal coke necessitate a considerable amount of binding material, and a coking coal is one in which sufficient binding material remains after the period of expansion (*i.e.*, when the plastic layer is bubbling and foaming) to allow the coke particles to be adequately cemented together during the shrinking process. With the production of a small-celled coke, such a large quantity of binding material is not required, and it is conceivable that a large proportion of the parent substance from which the binding material originates is distilled away and converted into volatile therms. The author believes that it is this binding material which is the origin of the additional therms produced in the rapid carbonisation of coal and in briquette carbonisation. In order to develop this hypothesis a further experiment will be shown in which equal weights of coal, in the form of coal alone and of a coal-coke mixture containing 25% coke, are heated in silica bulbs. The only difference between this experiment and the similar experiment already given is that on this occasion the silica bulbs are heated directly by means of Meker burners, so that there is developed a very high heat potential in relation to the weight of coal taken. In the previous experiment special means were adopted to maintain the necessary temperature of carbonisation with a considerably lower heat potential more in accord with large scale practice. It will be observed that the rate of gas evolution in the present experiment is practically the same in both cases, owing to the fact that the quantity of heat available is so great that the coal charge is heated just as rapidly as the briquetted mixture. Under such conditions of drastic heating it can be imagined that practically the whole of the binding material is converted into volatile matter.

Now this observation is of great interest to the gas chemist. It is often said—and with good reason—that the carbonisation of coal in the laboratory is of little value in forecasting the results eventually to be obtained on the large scale. That the laboratory distillation fails is due partly to the fact that the furnace is out of all proportion to the weight of coal charge used, and the amount of binding material evolved as volatile matter is higher than would be realised on the large scale. Further, the size of the retort in relation to the coal charge is also usually out of keeping with large scale conditions and a degree of tar cracking is practised which causes the results to be materially different from large scale experience. The

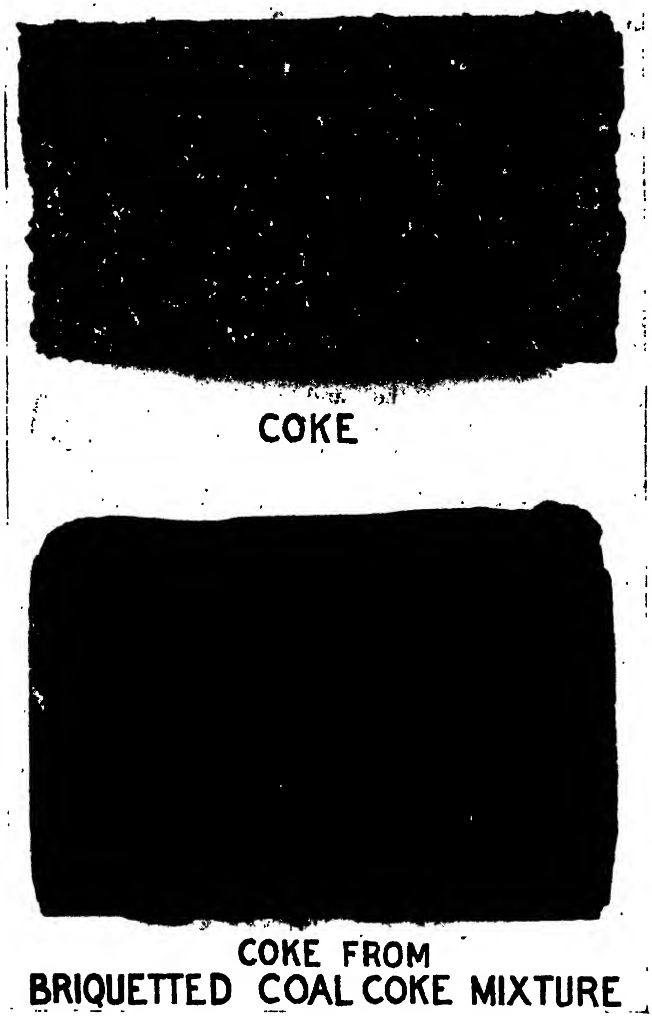

FIG. 31.

difficulty of designing laboratory apparatus to yield results comparable with large scale practice is generally realised, but the author does not know whether the underlying cause of these differences is appreciated.

If this hypothesis be correct—that the material which cements together the cell structure of coke may under certain conditions be distilled away as volatile matter—the question arises as to what is the maximum yield of volatile therms that may be obtained in the carbonisation of coal? This the author cannot answer, but one is faced with the fact that a small scale laboratory experiment (see Table E) yielded nearly 100 therms of volatile matter from a coal which under normal conditions of working has given only 90 and this improved yield should be the aim in large scale practice. It may be pointed out in passing that if this hypothesis regarding binding material be true then the usual test for volatile matter in coal is of very limited utility for computing the value of a coal for gasmaking purposes. The test is carried out by heating very rapidly an exceedingly small quantity of coal; and under these conditions of drastic heating the whole of the volatile matter is evolved, the coke is useless, and the result is one appreciably different from that realised on the large scale. What should be known in computing the value of a coal is the proportion of the total volatile matter which is recoverable as volatile therms

under the conditions of the practical process to be adopted.

It will be remembered that the carbonising experiments of the previous lecture indicated that not only a maximum volatile thermal yield was obtainable under the conditions of rapid heating, but also that moderately slow carbonisation was a tar conserving process and very slow carbonisation a coke conserving one. The conclusion was then arrived at that, in the slowest process, tar distillation took place as well as gas evolution and that the pitch left by the distillation of tar contributed to the yield of coke. It is now seen that, to a greater or less extent, the tendency to augment the coke yield takes place in all carbonisation processes and that the slower the process the greater the quantity of binding material left in the coke. It would appear that the thickness of the plastic layer is dependent upon the rate of heating and that a quickly heated coal will produce an unsatisfactory coke (unless some special means such as briquetting be adopted) for the binding material required for the purpose of cementing together the large cells will have been distilled away or cracked into gas before the shrinking process commences. This is actually the case; the most satisfactory coke is produced by heating very heavy charges for long periods, while the coke resulting from the rapid carbonisation of light charges yields a high percentage of breeze. The problem, therefore, resolves itself into either determining the minimum amount of binding material required for the coke to be a satisfactory material or, preferably, discovering some means of treating the coal substance prior to carbonisation so that upon cokification it will yield a product which requires a minimum amount of binding material to make it mechanically stable. The latter problem has already been solved, for it has been demonstrated that the carbonisation of briquetted coal-coke mixtures results not only in an increased yield of volatile therms, but also in a compact solid fuel which is far superior to ordinary coke. The author does not wish to overlook the point that carbonisation may take place under conditions which prevent a large degree of expansion of the coke, and it is possible that the prevention of expansion by compression may result in an enhanced degree of tar cracking. Such a process does not, however, result in the recovery of additional volatile therms, because the formation of the plastic layer is not avoided.

It is now proposed to examine briquette carbonisation from the point of view of the gas manufacturer and to discuss the advantages and disadvantages of such a carbonising system. There is no necessity to deal with the financial advantages accruing from the production of an additional 8 to 9 volatile therms per ton of coal carbonised, but at this stage it is proposed to consider what is perhaps equally important to the gas industry—namely, the production of a superior solid fuel. The author is certain that, if greater attention were paid to the manufacture of solid fuel, whereby its application might be greatly extended, a much wider market would be established, a greater throughput of coal would be possible, and the selling price of gas consequently reduced. Gasworks coke commands an excellent market and is so suitable a material in many industrial operations that it cannot be replaced, but its scope would be largely extended if we could render it suitable for those industries which to-day, for certain reasons, prefer to consume raw coal. By reducing the size of the cells present in the coke, by increasing its density and its combustibility, and by reducing the percentage of incombustible matter left in the ash, a solid fuel will be produced which will be of greater value to the industrialist than coal, because, in such a material, the therm will be generated with greater efficiency and with smaller expenditure on labour. Moreover, it is to be foreseen that, if briquetting becomes expedient, then the blending of coals prior to carbonisation will become possible. If this be done, an additional attribute of considerable value will be given to the solid fuel, for the production of a fuel of constant quality will effect an appreciable reduction in labour and control costs. The difficulties experienced in the working of gasworks plant owing to the varying quality of the coal employed are well-known. One of the distinct advantages of coal-gas is its constancy of quality, and the author now wishes to advocate that the gas industry should in the future undertake the responsibility of producing a solid fuel which is also of constant quality.

The whole organisation for dealing with the products of the distillation of coal—*i.e.*, gas, tar, ammonia and coke—exists in the gas industry, and it is to the gas industry that the nation should look for the manu-

facture of a solid fuel which shall completely displace the use of raw coal both in industrial and domestic appliances. It is required that our solid fuel business should extend in such a manner and with such an increased revenue per therm, that it will reduce the selling price of the gas therm, and so cause gas to be even more generally applicable than it is to-day. There is a strong public movement to achieve the smokeless city and our responsibility in the future must also extend to the supply of solid household fuel for the open fire. If we fail to undertake this responsibility, others will step in and succeed, and in the future we may regret having missed an excellent opportunity of expanding our business. The author is not advocating low temperature carbonisation, for he does not think that in the distillation of coal at low temperatures lies the solution of the household fuel problem. The low temperature process labours under all the disabilities incurred by the production of a plastic layer during the carbonising process. Not only is the distillation process a slow one, but in consequence of the production of the plastic layer, the resulting fuel is large celled and friable (unless special precautions be taken) while the binding material remaining in the coke is high. The distillation process is carried on until the coal charge has been brought into equilibrium conditions at approximately 600°C., and, as a result, some 6 to 10% of volatile matter remains equally distributed throughout the mass. Were the process arrested before equilibrium was attained, an uncarbonised core would result and the fuel would cease to be smokeless. It has already been indicated that in the case of coal-coke briquettes, the absence of the plastic layer allows heat to be transmitted so rapidly through the mass that, after the first three hours, the volatile matter is equally distributed throughout the coke.

Reference to the curves in Fig. 27 will show that if the charge had been withdrawn at the end of the first 3½ hours, 76% of the gaseous therms would have been evolved, and there would have remained 5.6% of volatile matter (17 therms) well distributed throughout the solid fuel. It is thus possible to arrest the high temperature distillation of briquettes after 3½ hours and find 5.6% of volatile matter equally distributed throughout each individual briquette, and this applies, in practice, to briquettes in the centre as well as at the periphery of the retort. This is an important observation, for low temperature carbonising effects as regards the resulting fuel may thus be obtained under high temperature conditions, with a throughput of coal and yield of gas and tar which are very high. The resulting fuel will constitute an excellent substitute for raw coal in the household fire. It will, in fact, be greatly preferred owing to its ease of combustion and its high radiation effect. It possesses, however, one great disability, which must receive careful attention and that relates to its ash content. In order to obtain excellent results in the household fire, the ash content of this solid fuel should not surpass 5 to 6%. The question of the advisability of effecting the separation of ash from the original coal will receive consideration later.

In addition to the two main claims of briquette carbonisation there are one or two incidental advantages which arise from practising this method of distillation. In the first place, it is now a practicable proposition to arrest the distillation process when the amount of work being effected is of such a low order and the cost of recovering the remaining gaseous therms so high, that the loss of gas is more than counterbalanced by the saving effected by the increased throughput of coal. Such a procedure would be impracticable if raw coal were undergoing carbonisation at a high temperature, for to arrest the process in this case would result in an unburnt core in the charge and this would create retort-house annoyance in addition to producing a friable coke from a portion of the charge. Further, it may also be of interest to point out that the introduction of briquette carbonisation in the gas industry would increase the range of coals suitable for gasmaking purposes. It will have been seen from the picture already drawn that a coking coal is one which, after the evolution of gas and the formation of large cells, shrinks to such an extent that the whole mass holds together. The subsequent shrinking operation in the case of briquette carbonisation is certainly important in determining the final density of the fuel and its combustibility, but it is not nearly so important as heretofore, and in consequence a much larger range of possible gasmaking coals is open to the gas industry.

The revolution which the introduction o

briquetted material may produce in the carbonisation process in horizontal retorts may, however, be small compared with the probable effect upon vertical retort practice. Carbonisation in vertical retorts possesses some distinct advantages over that in horizontal retorts, but it is essentially a tar-conserving process, and were it not the usual practice to steam the coal charge, the gaseous thermal yield would be relatively low. The increase in the rate of carbonisation which will result from the use of briquettes is likely to cause a higher gaseous thermal yield to be obtained in the vertical retort, and steaming may then only be practised for the production of a scouring gas, and to utilise the sensible heat of the coke retort complete supremacy in carbonising methods.

The main advantages to be derived from the introduction of briquette carbonisation have now been briefly dealt with and it may be of interest at this point to show the installation for grinding and briquetting which has been used in the preparation of the material for the above experimental trials (see Fig. 32). The engineering problems of briquetting are by no means simple, but E. R. Sutcliffe, who has supplied the necessary plant, has made a study of this problem for many years. On the right of the picture is seen a grinding mill, from which the powdered coal is transported by means of a screw conveyor to the charging hopper of the pressing machine. A briquette weighing some 2 lbs. is made at each stroke of the press and is discharged from the die on to the revolving table. The briquettes are seen lying on the left hand side of the picture.

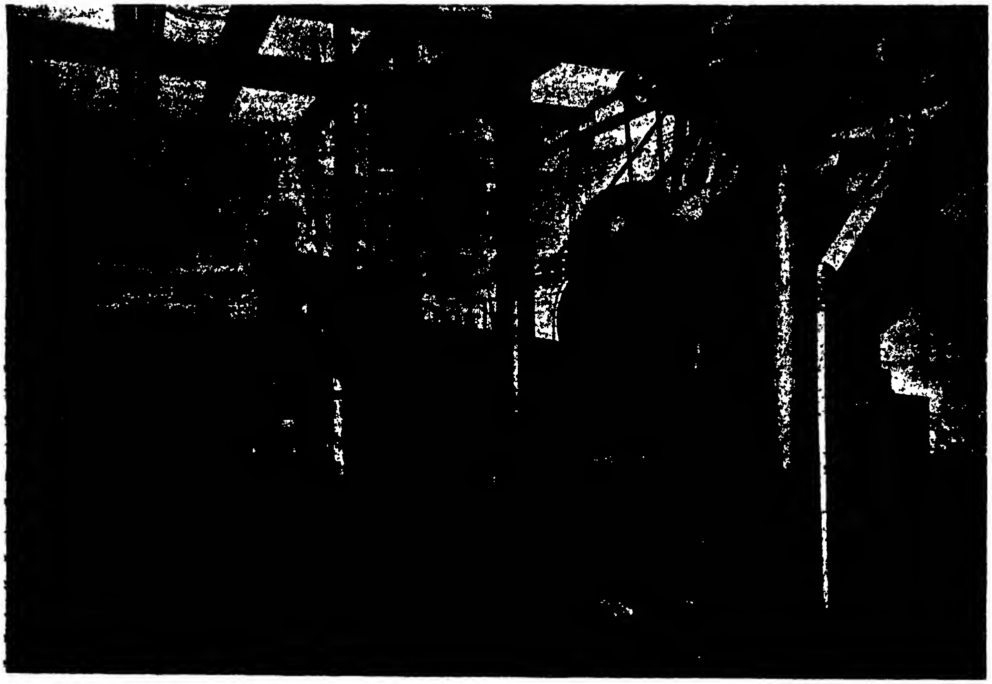

Fig. 32.

charge. But the advantages will not stop here for the admixture of a suitable proportion of coke or non-caking coal will reduce expansion during carbonisation and will prevent hanging up of the charge within the retort. Moreover, the choice of coals to be used in these installations becomes then almost unlimited. Whatever benefits the prevention of expansion and of the formation of the plastic layer in coal may bestow upon those employing horizontal retorts, the introduction of briquettes may constitute the one link necessary to give the vertical

With regard to the cost of grinding and briquetting, this is estimated by E. R. Sutcliffe and E. C. Evans to be of the order of 3s. 6d. per ton; this figure includes labour, wear and tear, depreciation and interest. The question may be raised as to whether briquetting coal prior to carboni-

sation is an economically sound proposition and whether the advantages to be derived from this process—namely, enhanced yield of volatile therms, increased throughput and a superior solid fuel—warrant this additional cost. This remains to be determined and several years of experience may be necessary before some of the suggested innovations in carbonisation are realised—if they ever are. It has, however, been necessary to deal in detail with the effect of briquetting in order to present certain aspects of this study of the carbonisation process.

The operation of grinding coal prior to briquetting carries with it several advantages and a few disadvantages. The outstanding disadvantage lies in the fact that coal in a state of fine division is liable to become oxidised, with consequent deterioration in its gasmaking qualities, and thus all plant utilised in grinding and briquetting should be so arranged that only inert gases are brought into contact with the finely divided coal. The author is not sure, in fact, that even this method of operation will entirely prevent some reactions proceeding which may slightly affect the value of the coal as a gasmaking material. Another disadvantage lies in the necessity for taking precautions against fire when dealing with finely powdered coal, although this latter question does not present any material difficulty.

The main advantages of possessing coal in a state of fine division relate to the possibility of chemical treatment being applied prior to carbonisation and to the increased facility with which the operation of de-ashing may be effected. Chemical treatment opens up the wide question of the possibility of hydrogenating the coal substance prior to carbonisation for the purpose of enhancing the yield of volatile products—a question upon which investigators are working at the present time—whilst de-ashing is a problem which is engaging considerable attention in the gas industry to-day. It has already been stated that a process for the removal of ash becomes necessary if we are to aim at the manufacture of a solid household fuel, but the author is not prepared to discuss whether the de-ashing of coal should take place at the colliery or at the gasworks. This question, among others, is determined by geographical position, ease of transit, etc. It is certain that, if the process be carried out at the pithead, the transit of inert material, as well as other labour costs, may be avoided. It will naturally be a question of economics whether or not de-ashing should be practised at the colliery, but it is to be imagined that a large gas undertaking with a favourable solid fuel market and a cheap means of transport is likely to find the de-ashing of coal at the works to be the more remunerative process.

The separation of ash from coal is a problem beset with difficulties, the most formidable of which is that of cost. The processes devised for this purpose fall into three categories :—

(1) Those dependent upon the difference between the density of coal and ash-bearing coal. (The Drescher Table.)
(2) Those based upon the difference in the co-efficient of friction of the coal and ash-bearing coal. (The Spiral Separator.)
(3) Those effecting separation of the ash by taking advantage of the characteristic surface tension effect of certain liquids. (The Minerals Separation, Ltd., Process and the Trent Process).

Most of the known processes have now been studied either directly or indirectly. Each possesses its special attributes and the choice between them largely depends upon the actual requirements of the coal user. Some of these processes effect a very efficient separation of ash and yield tailings containing as much as 70% of ash. Such a degree of separation is inclined to be costly and the author is of the opinion that if de-ashing is to be practised at the gasworks a less perfect process will be preferable. Such a process will be one in which the heads will contain a minimum percentage of ash, while the ash content of the tails will not be too high to prevent their being used in the gas producers required in the gasmaking process. In this way the gasworks would burn its own high ash-bearing coal or coke and at the same time be enabled to manufacture a solid fuel which is capable of becoming a keen competitor to raw coal. In this way, it would be possible to reach the desired goal—namely, the distillation of all raw coal, prior to use, at the gas undertaking of each township.

At this stage it is proposed to summarise the main conclusions which have been arrived at during these lectures and to review some of the earlier statements in the light of the information which has since been presented. The lectures as a whole have dealt with one aspect of the new interpre-

tation of the carbonising process which has arisen from the introduction of the therm system—namely, that the process is in reality one in which the therms of the original coal are distributed into the three forms, gas, tar and coke. No attempt has been made, however, to deal with the important question of heat expenditure during the carbonisation process. In Lecture I, consideration was given to the production of gaseous therms and to means for preventing their wastage in the retort house, while an attempt was also made to indicate the futility of computing the efficiency of a process on the basis of its gaseous thermal yield alone without giving consideration to the two subsidiary products, tar and coke, which are sources of potential therms. This theme was developed in the second lecture when the results of an investigation were submitted which indicated very clearly the inter-relationship existing between coke, tar and gas. These results revealed the fact that by modifying the rate of carbonisation it was possible to convert at will the process of carbonisation into a coke, tar or gas conserving process. Moreover, these results indicated that with very rapid heating, when the process was essentially a gas conserving one, the yield of volatile therms exceeded that normally obtained by 8 to 9 therms. It will be agreed that this observation is one of considerable importance to the gas manufacturer and in this lecture means have been considered for reproducing such results on a large scale. It has been shown that by admixing inert material such as coke with the original coal a rapid rate of heat transmission is attained which results in enhanced yields of volatile therms. Such an innovation in the carbonising process opens up new vistas of possibilities in the development of the gas industry and consideration has been given to some of the radical changes which would be effected both in horizontal and vertical retort practice if briquette carbonisation ever became an accomplished fact. The subject is, however, in its infancy, but it is probably along these lines that future progress in the gas industry may be effected.

It will be seen that the first lecture presented certain facts which may be applied in practice to-day; the second also presented facts but referred to those culled in the laboratory, while the present lecture deals with a few results, and also with a hypothesis which should be treated entirely as such.

All the work has received the inspiration and guidance of my chief, Dr. Carpenter, who more justly should have delivered these Cantor Lectures.

Finally it may be imagined that the large amount of work collected together could only have been carried out with the help of able assistants. It would be difficult to name all who have contributed in their work to the preparation of these lectures. I, therefore, desire to tender my thanks to three senior assistants, Harold Hollings, M.Sc., Harold Stanier, B.A., and Edith Langdon, B.Sc.

PENCIL CEDAR FROM EAST AFRICA.

The timber resources of Kenya Colony have recently been surveyed by the Government and the findings made public. In general it is believed that, for the present, transportation is too little developed in the colony to allow of the profitable exportation of either hewn or sawn timber of ordinary kinds since the regions of supply are hundreds of miles inland. It is thought, however, that certain specialties could be handled with profit at present.

According to the United States official "Commerce Reports," the specialty which will probably first receive the attention of the exploiters is a wood locally known as "mutarawka" (*Juniperus procera*) which it is thought will form a most excellent substitute for the American pencil cedar now in use, which is reported to be rapidly disappearing. Mutarawka is found in the highland forests of the district and is shipped from Mombasa. It is described as a handsome reddish brown softwood with fine even grain which saws, planes, and works up well, is rather brittle, very fissile and, like the original pencil cedar, aromatic. Its chief claim, however, is that it possesses in a high degree that quality indispensable to pencil wood, namely, it whittles well. It is said to be somewhat harder than the *Juniperus virginiana*, but experts believe that the degree of hardness depends very largely upon the age of the tree when cut and the methods of seasoning. The exact quantity of standing timber now available is not yet calculated, but it is estimated that sufficient supplies are available to keep up a sustained export in pencil slats until such time as reforestation, which could be started immediately, would be ready for exploitation. The wood is at present attacked by a fungus, which renders many of the largest and oldest logs subject to internal cavities. This is now being studied with the idea of control and elimination, but for a wood supply to be used for pencils the defect is not considered a serious drawback.

CZECHOSLOVAK FLOUR-MILLING.

Flour mills, naturally of primitive type, are recorded as existing in Bohemia as early as in the 8th century, and windmills are mentioned in chronicles from the commencement of the 11th century onward. By the year 1605, the number of mills in Bohemia driven by water-power alone was 8,500, and this total continued to increase until the introduction of modern machinery, which began about the year 1846. From the time that the milling process began to be industrialised, the mills have declined in number, but those surviving have, of course, increased in size and output.

The 6,940 mills existing, for example, in Bohemia in the year 1875 had declined by the year 1902 to 5,547. At the present moment there are, throughout the whole of Czechoslovakia, 10,715 flour mills, which normally give employment to about 30,000 workpeople. Of these mills, 5,276 are in Bohemia, 2,100 in Moravia, 337 in Silesia, 2,500 in Slovakia, and 502 in Carpathian Ruthenia.

The normal output of the flour mills of Czechoslovakia is placed at, roughly, 5,187,000 tons per annum. On the other hand, the total consumption of the country (for a population of approximately 14,000,000) is about 3,180,000 tons. Wheat and rye, however, are grown in Czechoslovakia to the extent of only 2,100,000 tons annually, so that considerable imports are necessary, and these may, of course, take the form of either grain or flour.

Unfortunately for the Czechoslovak flour-milling industry, the imports of milled products are greatly in excess of those of grain. In 1923, some 220,000 tons of flour were imported, as compared with only 14,000 tons of wheat and rye grain, and in the first three months of the current year, although grain imports have risen to 35,130 tons, compared with 2,517 tons for the same period last year, the flour imports have also risen, totalling 67,265 tons, as against 48,971 tons in the first three months of 1923.

The main imports affecting the milling industry came last year from the following countries:

	Wheaten flour.	Wheat and Rye grain.
	(Value of imports in Czechoslovak crowns.)	
Germany	176,523,059	5,636,040
Hungary	120,506,586	1,966,931
U.S.A.	87,728,297	2,510,334
France	56,455,286	—
Hamburg	49,734,451	—
Austria	46,879,196	6,786,271
Holland	29,806,056	131,803
Great Britain	9,297,796	—
Yugoslavia	2,509,911	8,425,188
Rumania	2,509,294	146,648
Brazil	—	390,170
Canada	—	325,910
Argentine	—	271,102
Other countries	20,337,562	9,309,432

The Federation of the Czechoslovak Millers have made repeated efforts to convince the authorities of the necessity for measures to protect the milling industry. These efforts have not yet met with success and the situation of the mills remains precarious.

Many of the flour mills utilise the flour they mill in their own bakeries, turning out bread, etc., in considerable quantities. One concern of this kind bakes 80,000 loaves per day besides some 150,000 cakes, rusks, etc.

The modern machinery and equipment of the flour mills is entirely made in Czechoslovakia, several of the leading engineering works specialising in this and other mill and factory plant.

CZECHOSLOVAK EXPORTS AND IMPORTS.

The value of Czechoslovakia's imports in June was Kc 1,230,125,178, compared with Kc 1,575,688,150 in the previous month—a reduction of some 345 millions. Exports for June were also lower than the May figure. There was a favourable balance of trade in June of 96 million crowns, while for the first six months of the year the favourable balance was as follows:—

Jan.-June:	Weight in tons.	Value in Czechoslovak crowns:
Exports	6,208,876	Kc 7,831,662,228
Imports	2,267,044	7,263,321,362
	3,941,832	568,340,866

There is thus a favourable balance of over 568 million crowns for the first six months of the current year. Last year the figure was 1,540 millions, and the difference is due to this year's largely increased imports. At the same time the bulk of trade altogether shows a very satisfactory increase, the comparative figures for the two years being:

	1924	1923
Exports	Kc 7,831,662,228	Kc 5,619,107,552
Imports	7,263,321,362	4,072,939,832

The bulk of trade has, therefore, increased by over 50% compared with 1923. The main items of import in June were (in millions of Czechoslovak crowns):

Raw cotton and yarns	236
Grain, flour, pulse	235
Wool, woollen yarns	153
Fats	61
Cattle	42
Fruit vegetables	40
Silk and silk goods	38
Minerals	36

Other imports in June included iron and hardware (33 million crowns), animal products (32 millions), timber and coal (3), flax, hemp and jute (29), common metals (29), tobacco* (22), chemicals (21), waste (17), mineral oils (17), leather (16), Italian wares (13), paints, colours, perfumery (11), rubber and caoutchouc (11), instruments, clocks and watches (10).

Practically all imports show an increase compared with last year, only the item of fats having declined considerably.

The following table shows the imports from the various countries :—

	June 1924	June 1923	January to June 1924	January to June 1923
	(in millions of Czechoslovak crowns).			
Germany ..	433	345	2513	1674
Austria	101	50	570	254
Italy	92	34	591	178
Hungary ..	77	18	324	130
U.S.A.	62	48	460	314
England ..	49	31	210	146
Poland	47	16	256	119
Holland ..	35	34	182	187
France	33	33	263	143
Rumania ..	32	7	204	67
Switzerland ..	30	19	194	87
Yugoslavia ..	20	15	150	114
Belgium ..	7	6	58	34
Other countries	211	105	1289	623

Imports in June from the United States declined as compared with the figure of 111 million crowns' worth in May. Imports from England, on the other hand, improved from 44 millions in May to 49 in June, the latter figure being well over the monthly average. Last year America was third on the list of countries from which Czechoslovakia gets her imports; this year she is fourth. England which, early this year, dropped low on the list has risen to seventh.

INDUSTRY IN TURKEY.

Turkey has never been an industrial country. Few factories existed in pre-war days, factory industry being far less important than domestic handicraft. In districts served by railways, domestic handicraft has also declined, peasants finding it more profitable to export their raw materials and buying foreign goods brought within their reach by railway transport.

Industry and domestic handicraft have suffered considerably through military operations, terminating with the Greek debacle and the partial destruction of Smyrna's industrial and commercial centres, as well as those in other localities, of the vilayets of Aidin and Hudavindikiar (Broussa) during the Greek retreat and the Turkish advance. Lack of skilled labour, due to the exodus of the Christian element, is considerably prejudicing the remaining industries in these localities.

In his Report on the Economic and Commercial Conditions in Turkey, the Commercial Secretary at Constantinople remarks that it is not possible at this juncture to form a correct estimate of the ravages caused by the unfortunate campaign in Anatolia. Previous to the war no statistics of Turkey's factory industry and handicraft were ever published.

Statistics were prepared in 1921 by the Government of Angora, but they only covered areas under its direct administration, which did not constitute the richer industrial centres, such as those of the vilayets of Smyrna, Hudavindikiar (Broussa), at that time in Greek occupation, as well as Constantinople, then occupied by the Allies. These statistics are interesting however, as showing how unimportant Turkey's factory industry and domestic handicraft were in 1921 in the areas controlled by Angora's administration.

The richer industrial centres have suffered very heavily, especially those in Smyrna and neighbourhood, in the Broussa district, and in some regions situated in the Asiatic littoral of the Sea of Marmora. The following is an estimate of the value of the output of some of the industries and handicraft furnished in the statistics referred to above :—

	Value of output. Piastres.
Tinware	1,150,000
Copperware	3,127,000
Cutlersware	1,476,000
Sawmills	818,000
Ironware	1,318,000
Armourers	436,000
Cast metalware	337,000
Native stoves	2,476,000
Cartwrights and manufacturers of agricultural machinery	64,762,000
Jewellers	1,455,000
Stone and earthenware ..	114,182,000
Carpentry	9,264,000
Woodturning	2,481,000
Saddlers	9,852,000
Confectionery	14,667,000
Preserved meats, etc. ..	30,468,000
Flour mills	214,530,000
Macaroni factories	3,426,000
Olive oil factories ..	11,607,000
Total	487,832,000

GENERAL NOTE.

Census of French Sawmills.—A census of the number of sawmills, both fixed and portable, existing in France, was taken recently by the Administration des Eaux et Forêts. According to a report furnished by the United States Assistant Commercial Attaché in Paris, the total is 10,835, of which 1,471 are portable. The daily capacity of output is 29,468,000 feet, of which 3,392,000 feet constitute the output of the portable mills. The Bordeaux District, with 892 sawmills and a daily productive capacity of 3,445,848 feet, is the most important. Other districts where the daily productive capacity is over 848,000 feet are Paris, Rouen, Chambery, Amiens, Epinal, Alençon, Tours, Moulins, Niort, Aurillac, and Strasburg. Of the sawmills, 8,695 have a daily output of less than 4,240 feet, although their total capacity output is 13,313,600 feet.

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICES.

OPENING OF THE 171st SESSION.

The Opening Meeting of the 171st Session will be held on Wednesday, November 5th, when an address will be delivered by Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., Chairman of the Council. The chair will be taken at 8 p.m.

DOMINIONS AND COLONIES SECTION.

A meeting of the Dominions and Colonies Section Committee was held on Friday, October 10th. Present—Lord Blyth (Chairman of the Committee) in the chair, Sir Charles H. Bedford, D.C.L., LL.D., D.Sc., M.D., Mr. Byron Brenan, C.M.G., Hon. Sir John A. Cockburn, K.C.M.G., Hon. H. P. Colebatch (Agent-General for Western Australia), Mr. Edward Dent, M.A., Hon. G. Fairbairn (Agent-General for Victoria), Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., and Sir Charles Metcalfe, Bt., with Mr. G. K. Menzies, M.A. (Secretary of the Society), and Mr. S. Digby, C.I.E. (Secretary of the Dominions and Colonies and Indian Sections).

REPRINT OF COBB LECTURES.

The Cobb Lectures on "Certain Fundamental Problems in Photography" by T. Slater Price, O.B.E., D.Sc., F.I.C., F.R.S., Director of Research to the British Photographic Research Association, have been reprinted from the *Journal*, and the pamphlet (price 3*s*.) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.2.

A full list of the lectures which have been published separately and are still on sale can also be obtained on application.

REPORT ON THE SOCIETY'S EXAMINATIONS, 1924.

The Council have much satisfaction in reporting that the total number of candidates entering for the Society's examinations in 1924 again constitutes a record. The figure this year is 67,282, as compared with 64,518 in 1923, which was up till then a record. The curve on page 828 shows how the numbers have grown since the year 1900.

The remarkable increase seems amply to justify the policy adopted by the Council in regard to the conduct of the examinations. They appointed a very strong Committee, which includes representatives of the Board of Education, the London County Council, various other local education authorities, and several important commercial schools. In this way the Council are kept extremely well informed of the needs of students, and they are able to modify or add to the examination syllabuses as occasion may arise. This year, for instance, three new subjects were added, viz., Foreign Exchange, Stock Exchange Law and Practice, and Advertising and Salesmanship; next year Costing will be included; and the Council will always be ready to make further additions as soon as they are assured that there is a genuine need for them.

In order to encourage students to take up group courses of subjects, the Council have decided to offer prizes to the value of £200 in 1925. Fourteen prizes of £10 each will be offered to candidates who are awarded group certificates in commercial subjects in Stage III., and twelve prizes of £5 each will be offered to candidates who are awarded group certificates in Stage II. The regulations relating to these group certificates will be found on page 13 of the Syllabus of Examinations, 1925.

The value of the certificates is becoming more and more widely recognised every year. Many important business and industrial firms encourage their employees to enter for these examinations, and some

grade their junior staffs according to the successes which they obtain.

The Examinations were held, as usual, at two periods, April and May-June. In April the number of entries was 27,273, and in May-June, 43,805. The papers worked were divided between the two Examinations as follows :—

	April.	May-June.	Total.
Advanced Stage	2,731	6,345	9,076
Intermediate Stage ..	8,2061	6,808	25,014
Elementary Stage ..	16,336	20,655	36,991

In addition to the 67,282 papers worked in the written examinations, 795 candidates presented themselves for the *viva voce* Examinations in Modern Languages.

The subjects of Examination this year were :—

Arithmetic.
English.
Book-keeping.
Shorthand.
Typewriting.
Economic Geography.
Economic and Social History.
Economic Theory.
Précis-writing.
Commercial Correspondence and Business Knowledge.
Commercial Law.
Company Law.
Accounting.
Banking.
Foreign Exchange.
Theory and Practice of Commerce.
Railway Law and Practice.
Railway Economics.
Shipping Law and Practice.
Stock Exchange Law and Practice.
Insurance Law and Practice.
Advertising and Salesmanship.
French.
German.
Italian.
Spanish.
Russian.
Danish and Norwegian.
Dutch.
Swedish.

Arithmetic.—The total number of papers worked in all three stages was 7,465, as compared with 6,568 in 1923. In Stage III. the number of candidates was 291, of whom 30 obtained first-class certificates, 111 obtained second-class certificates, and 150 failed. The proportion of failures is a good deal higher than it ought to be; the examiner still finds it necessary to draw attention to great weakness in mensuration and the use of Logarithms, and the application of compound interest to annuities and kindred problems.

In Stage II there were 1,760 candidates, of whom 296 obtained first-class certificates, 883 obtained second-class certificates, and 581 failed. A large proportion of the candidates had evidently not been properly prepared in the subjects of the syllabus, while many failures were due not so much to inaccuracy of calculation as to want of intelligence in reading the questions and grasping their meaning.

In Stage I, out of 5,414 candidates, 3,810 passed and 1,604 failed. It is satisfactory to note that the examiner reports a general improvement in the style of the working, but again he has to draw attention to the lack of common sense on the part of some candidates. Thus, in one paper the cost of gravel for a garden path was given as £1,131,642,159 12*s.* 8*d.*, while in another the number of paupers on every 1,000 acres was given as 27,173,898,380,190.

English.—The importance of English as the basis of any sound education in this country can hardly be over-estimated. Over and over again have examiners in almost all subjects of the Society's examinations drawn attention to the fact that candidates are very deficient in the power of expressing themselves, and that even in the higher stages many make the most elementary mistakes in spelling, grammar and composition. There is some satisfaction in noting that the number of those entering for the examination in English is steadily growing. This year the total was 5,690, as compared with 4,997 in 1923, and 3,790 in 1922; but the quality of much of the work submitted was very poor, and in view of the large number of candidates in all subjects, 67,282, one cannot but feel that the proportion of those taking English ought to be very much larger than it is.

In Stage III there were 337 candidates, of whom only 20 obtained first-class certificates, 160 obtained second-class certificates, and 157 failed. While much of the work submitted was fairly good, very little of it

was really excellent. Many of the candidates would have done well in Stage II, but fell short of the requirements of Stage III, where both the standard and the passmark are very considerably higher. The examiner comments on the tendency of students to use such worn out phrases as "wend our way," "feathered tribe," etc. Teachers cannot impress upon their pupils too strongly the value of a simple and direct style, free from the "flowery" and the meretricious.

In Stage II there were 1,505 candidates, of whom 93 obtained first-class certificates, 984 obtained second-class certificates, and 428 failed. As in Stage III, the proportion of first-class work is disappointingly small, and here again the examiner has to complain that the style of many of the essay-writers suffers from the same faults as those commented on in Stage III.

In Stage I there were 3,848 candidates, of whom 2,127 passed and 1,721 failed. The total number of entries shows an increase of exactly 600 over the corresponding figure for last year, but unfortunately, it seems to be the bad centres which contribute most to the increase. A good many of these candidates are a good deal below any reasonable standard of examination, as will be seen from some of the specimens of answers quoted by the examiner in his report.

Book-keeping.—This continues to be far and away the most popular subject of examination, the total number of entries being 20,409. In Stage III there were 3,448 candidates, of whom 422 obtained first-class certificates, 1,496 obtained second-class certificates, and 1,530 failed. The leading papers were exceptionally good. Some candidates possessed little or no knowledge of the forms of various registers in the case of limited companies, and many were at fault in their treatment of debentures issued as collateral security for a loan, while in numerous cases neatness was wanting in the worked exercise.

In Stage II there were 7,375 candidates of whom 866 obtained first-class certificates, 4,541 obtained second-class certificates, and 1,968 failed. It is very satisfactory to note that the examiner reports a distinct improvement this year in the standard of first-class papers.

In Stage I there were 9,594 candidates, of whom 5,890 passed and 3,704 failed. Here, too, there is a distinct improvement in the work submitted by candidates as compared with former years. The examiner, in his report, draws attention to a number of points in which candidates showed weakness, and teachers would do well to study these comments and to bring them to the notice of their students.

Shorthand.—The number of entries in this subject has again increased, the total figure being 13,518, as compared with 12,679 in 1923, and 11,229 in 1922. In Stage III. there were 1,273 candidates; 88 passed the test at 140 words per minute; 180 at 120 words a minute, and 1,005 failed. These results are extremely disappointing, and the examiner has taken a great deal of trouble to ascertain the causes of the heavy percentage of failures. He finds that the average age of candidates entering for Stage III. in shorthand is lower than that of those entering for the same stage in other subjects, and consequently their knowledge of English cannot be expected to be so good as that of candidates whose studies have extended over a longer period. Further, there are evidences that many of the candidates have attempted to acquire speed too quickly, a practice far too common now-a-days; while in many cases candidates, instead of being content to complete one of the passages and to do it well, attempted both passages and finished neither.

In Stage II. there were 6,132 candidates, of whom 1,111 passed the test at 100 words per minute, 2,676 at 80 words per minute, and 2,345 failed. The work submitted was very fair, and the spelling on the whole was good. The word "pneumatics" seemed to be quite unknown to many candidates, one of whom transcribed it as "auctomatacus."

In Stage I. there were 6,113 candidates; 2,471 passed the test at 60 words per minute, 2,022 at 50 words per minute, and 1,620 failed. The results here were very satisfactory, and there was a noticeable improvement in the spelling.

Typewriting.—It is very regrettable that the examiner should have to comment on the bad spelling of candidates in all stages of the typewriting examination. A typist who cannot spell correctly is of little use to anyone, and this brings us back once more to the point on which we have had to insist so often in former years, that a sound knowledge of English is essential as a preliminary basis for preparation for any subject of study in this country. In Stage III, at all events, where a first-class certificate is recognised by

many educational authorities as a Teachers' qualification, serious misspellings should be unthinkable. Apart from this failing, the work appears to have been on the whole quite excellent.

In Stage III there were 596 candidates of whom 120 obtained first-class certificates, 360 obtained second-class certificates, and 116 failed. In Stage II there were 2,356 candidates, of whom 1,055 obtained first-class certificates, 1,070 obtained second-class certificates, and 231 failed. The papers worked in this stage were particularly good, as the results show; and quite a large number of candidates made over 90 per cent. of the marks.

In Stage I there were 3,524 candidates, of whom 2,482 passed and 1,042 failed. The examiner in his report quotes a number of misspellings which are deplorable. The exercise of the least grain of commonsense would have saved the candidate from stating that the training ship *Exmouth* was "dry-docked and her boots cleaned."

Economic Geography.—In Stage III there were 49 candidates (as against 33 last year), of whom 4 obtained first-class certificates, 31 obtained second-class certificates, and 14 failed. The examiner reports that this year there is a real change of standard, the work being altogether better than on previous occasions. Apparently, however, teachers have not yet learnt the necessity of instructing their pupils as to the really important features of relief maps.

In Stage II there were 158 candidates. Unfortunately, the examiner was not able to award a single first-class certificate, 94 candidates obtained second-class certificates, and 64 failed. The quality of the papers worked in this stage is as discouraging as that of the Advanced Stage is encouraging. Over 60 per cent. of the candidates only secured from 40 to 50 marks, while two or three failed to obtain 8 per cent. of full marks.

In Stage I there were 292 candidates, of whom 185 passed and 107 failed. On the whole the general standard of the work seems to be steadily improving, but the examiner draws attention to the tendency of candidates to misread the questions. This gives evidence of insufficient training in regular examination work; for no candidates doing regular examination work and being properly penalised for careless reading of the questions set could make the mistakes shown in these papers as a whole. It is earnestly hoped that teachers will make a note of this point.

Economic and Social History.—There is a satisfactory increase in the number of candidates taking this subject, the figure being 146, as compared with 48 last year. In Stage III there were 17 candidates. Only one failed, but on the other hand only one obtained a first-class certificate. The general level of the work was satisfactory, and gave evidence of careful and intelligent study. In Stage II there were 44 candidates, of whom 5 obtained first-class certificates, 22 obtained second-class certificates, and 17 failed. The papers varied widely in quality, the best being of considerable excellence, and the worst bad failures. In Stage I there were 85 candidates, of whom 49 passed and 36 failed. None of the work submitted reached a very high standard.

Economic Theory.—The total number of entries in this subject was 378, as compared with 355 in 1923. In Stage III there were 150 candidates, of whom 17 obtained first-class certificates, 90 obtained second-class certificates, and 43 failed. A considerable number of the papers were creditable, and some remarkably good. In Stage II there were 228 candidates, of whom 12 obtained first-class certificates, 155 obtained second-class certificates, and 61 failed. While some of the questions were answered well, there were very few papers in which a high level was maintained throughout.

Précis-writing.—The number of candidates taking this subject continues to be small, indeed, there is a slight decrease as compared with last year, the respective figures being 101 and 113. On the other hand, the examiner reports a continuance of the general improvement in the standard of work which he noticed in 1923. In Stage III there were 46 candidates, of whom 6 obtained first-class certificates, 30 obtained second-class certificates, and 10 failed. In Stage II there were 55 candidates, of whom 10 obtained first-class certificates, 31 obtained second-class certificates, and 14 failed.

Commercial Correspondence and Business Knowledge.—The total number of entries in this subject was 3,996. In Stage III there were 101 candidates, of whom 8 obtained first-class certificates, 42 obtained second-class certificates, and 51 failed. In Stage II there were 951 candidates, of whom 72 obtained first-class certificates, 708 obtained second-class certificates, and 171 failed. In Stage I of 2,944 candidates, 1,931 passed and 1,013 failed.

Commercial Law.—433 candidates entered in this subject. In Stage III there were 162, of whom 45 obtained first-class certificates, 80 obtained second-class certificates, and 37 failed. There were several brilliant papers, but, speaking generally, candidates were not well grounded in the law of bankruptcy, and a more detailed and exact knowledge of this branch of the syllabus will be expected in future. In Stage II there were 271 candidates, of whom 71 obtained first-class certificates, 159 obtained second-class certificates and 41 failed. The examiner reports that the work was not up to the usual high standard shown by candidates in this examination, the two commonest faults being inaccuracy and irrelevance.

Company Law.—The total number of entries in this subject was 308. In Stage III there were 111 candidates, of whom 20 obtained first-class certificates, 64 obtained second-class certificates, and 27 failed. A number of excellent papers were worked which showed not only a grasp of fundamental principles, but a knowledge of detail and a familiarity with leading cases. Most of those who failed would have been better advised to attempt the Intermediate examination. In Stage II there were 197 candidates, of whom 67 obtained first-class certificates, 123 obtained second-class certificates and only 7 failed. Most of the papers showed an intelligent knowledge of the elementary principles of Common Law, and gave evidence of skilful teaching combined with careful study. It is curious that the examiner finds it necessary again to comment on the erroneous statement of a candidate, which was referred to in his report last year, that the Royal Society of Arts is a trading company which has obtained permission of the Board of Trade to omit the word "limited" as the last part of its name. How the statement came to be made in the first place is difficult to understand; how it came to be repeated is incomprehensible.

Accounting.—The number of candidates in this subject was 623, of whom 70 obtained first-class certificates, 284 obtained second-class certificates, and 269 failed. The work submitted was of average merit. Many candidates showed a lack of knowledge of costing: this is a subject of great and growing importance, and it is hoped that its addition as a special subject of examination in next year's syllabus will lead to its receiving more careful attention in future.

Banking.—Only 31 candidates entered for this subject, of whom 5 obtained first-clas certificates, 10 obtained second-class certificates, and 16 failed. The examiner complains that, as was the case last year, candidates showed lack of knowledge of bank book-keeping.

Foreign Exchange.—This subject, introduced for the first time this year, attracted 25 entries in all. In Stage III there were 11 candidates, of whom 1 obtained a first-class certificate, 8 obtained second-class certificates and 2 failed. In Stage II, of 14 candidates, 4 obtained first-class certificates, 7 obtained second-class certificates, and 3 failed. Once more the examiner has to complain of the very defective command of English possessed by the candidates generally.

Theory and Practice of Commerce.—The total number of entries in this subject has risen from 768 in 1923 to 1,040 this year. 182 candidates entered in Stage III, of whom 23 obtained first-class certificates, 90 obtained second-class certificates, and 69 failed. In Stage II there were 479 candidates, of whom 24 obtained first-class certificates, 293 obtained second-class certificates, and 162 failed. In Stage 1, of 379 candidates, 254 passed and 125 failed. In last year's report it was mentioned that entirely new syllabuses had been prepared in all three stages of this examination, and it is satisfactory to note that the results this year have been far more normal than was the case in 1923. There would still appear to be difficulties in finding sufficient suitable teachers of this subject, but the Examinations Committee has brought this fact to the notice of the London County Council, and it is hoped that means may be found to provide special training for this purpose.

Railway Law and Practice.—The examiner again reports an improvement in the quality of the work submitted in this subject, but unfortunately, the number of entries continues to fall, being 58 as against 107 in 1923, and 207 in 1924. Of these, 11 obtained first-class certificates, 32 obtained second-class certificates, and 15 failed. In view of the very large staffs attached to the many railway companies of the country, this decrease is distinctly disappointing. While the candidates generally have shown a sound knowledge of the law, many of them appear to be using out-of-date editions of text-books.

Railway Economics. — 29 candidates entered this subject, of whom 6 obtained first-class certificates, 15 obtained second-class certificates, and 8 failed. For the most part they appeared to be well grounded in the subject, but the number in the first-class would have been considerably greater had the candidates been more careful to write exactly on the points mentioned in the questions.

Shipping Law and Practice.—The number of candidates this year was 33, as against 21 last year, but this is still a very exiguous figure compared to the great size and importance of the shipping industry. 5 candidates obtained first-class certificates, 15 obtained second-class certificates, and 13 failed. Many of the entrants showed distinct ability in dealing with the problems and cases set in the question paper, but there was a general weakness in explaining legal terms.

Stock Exchange Law and Practice.—The examination in this subject, held for the first time this year, attracted 45 candidates. In Stage III there were 23, of whom 3 obtained first-class certificates, 13 obtained second-class certificates, and 7 failed. In Stage II 8 obtained first-class certificates, 8 obtained second-class certificates, and 6 failed. The examiner reports that on the whole the papers in both stages were very fairly done, but a number of candidates did not possess sufficient command of English to express themselves properly.

Insurance Law and Practice.—Of the 19 candidates in this subject, 4 obtained first-class certificates, 13 obtained second-class certificates, and 2 failed. The results are satisfactory, though not quite as good as in 1923, when there were 25 candidates. Very few were able to define insurable interest, or to give a concise statement of the law as to disclosure of material facts.

Advertising and Salesmanship.—This subject, introduced into the syllabus for the first time this year, attracted 41 candidates, of whom 7 obtained first-class certificates, 28 obtained second-class certificates, and 6 failed. With few exceptions the work submitted gave evidence of careful preparation, intelligent study, and sound knowledge of the theory of advertising. Some of the answers were exceedingly good.

MODERN LANGUAGES.

French.—The total number of candidates in French this year was 4,808. In Stage III there were 612 candidates, of whom 77 obtained first-class certificates, 293 obtained second-class certificates, and 242 failed. Some excellent work was submitted: indeed, the examiner reports that among the April papers was some of the best work he has ever had the pleasure of examining in a long experience: one of them was practically flawless, and secured full marks—a very rare thing. The number of first-class candidates would have been considerably higher but for weakness in syntax shown by otherwise good students.

In Stage II there were 1,799 candidates, of whom 119 obtained first-class certificates, 1,020 obtained second-class certificates, and 660 failed. The work shows that French is being carefully taught by a large number of skilful teachers with very satisfactory results.

The Examiner in Stages III and II has been at considerable pains to draw up a long statement containing advice, based on wide experience, as to the best means of studying French. This contains some exceedingly practical and valuable hints, and it is earnestly hoped that all students entering for the Society's examinations in French will carefully digest them and cultivate some of the admirable practices which he suggests.

In Stage I there were 2,397 candidates, of whom 1,879 passed and 518 failed. The general results were satisfactory, and it is gratifying to know that the grammatical questions were answered better than in previous years.

German.—In Stage III there were 58 candidates, of whom 24 obtained first-class certificates, 21 obtained second-class certificates, and 13 failed. In Stage II there were 136 candidates, of whom 18 obtained first-class certificates, 73 obtained second-class certificates, and 45 failed. In Stage I, of 141 candidates, 80 passed and 61 failed. Unfortunately, the standard of work generally was not high, great weakness being shown in elementary syntax and grammar, even in the advanced stage; but happily, there was a marked improvement in this respect among the candidates for the Stage I examination in April.

Italian.—In Stage III there were 17 candidates; 2 obtained first-class certificates, 13 obtained second-class certificates, and 2 failed. In Stage II, of 25 candidates, 1 obtained a first-class certificate, 17 obtained second-class certificates, and 7 failed. In Stage I there were 56 entries; 36 candidates passed and 20 failed.

Spanish.—The total number of candidates taking this subject was 638. In Stage III there were 99, of whom 11 obtained first-class certificates, 67 obtained second-class certificates, and 21 failed. As a result of this examination the examiner concludes that the student who devotes his attention to learning the language thoroughly without limiting himself to what he considers its purely commercial aspect, makes much more rapid progress. "Whereas the literary candidates display a sound knowledge of grammar and a good acquaintance with modern authors—in some cases of more extended periods of literature and history—the commercial candidates are distinctly inferior, and show the weakness of their acquirements by inventing words and making use of French or Italian expressions or terms of speech."

In Stage II, of 242 candidates, 27 obtained first-class certificates, 183 obtained second-class certificates, and 32 failed. The composition and essays showed a fair amount of promise, but weakness in grammar accounted for the small number of first-class awards.

In Stage I 244 candidates passed and 53 failed. The general average of the work submitted was very satisfactory, but the examiner still considers that there is a lack of adequate verb drill.

Russian.—This subject shows no sign of recovering the popularity which it enjoyed when the "Russian steam-roller" was expected to flatten out our enemies before it. In 1917 there were 266 entries; this year there were only 22. In Stage III, of 3 candidates, one obtained a first-class and 2 obtained second-class certificates. The work of the first candidate, who secured the Russian Embassy Prize, is described by the examiner as "almost perfect." In Stage II there were 7 candidates, of whom 4 obtained first-class certificates, 2 obtained second-class certificates, and 1 failed. The work done here was very satisfactory. In Stage I, of 12 candidates, 9 passed and 3 failed. The answers were of very moderate quality and show that candidates are apt to enter for this examination at too early a stage in their preparation.

Danish and Norwegian, Dutch, and Swedish.—For several years examinations have not been held in these languages, but as a certain number of students were anxious to enter this year, it was decided not to disappoint them. Unless, however, the numbers increase, it will not be possible to hold examinations in future years, except perhaps at rare intervals. In Danish and Norwegian there were 10 candidates. In Stage III 2 entered, of whom one obtained a first-class certificate, and one failed. In Stage II 8 entered, of whom 5 obtained first-class, and 3 second-class certificates. In Dutch, 4 candidates entered for Stage II, 2 obtained second-class certificates and 2 failed. In Swedish also, 4 candidates entered for Stage II, of whom one obtained a first-class, 2 obtained second-class certificates, and one failed.

ORAL EXAMINATIONS.

The results of the Oral Test which is now compulsory for all Candidates in the Advanced Stage of French, German, Spanish and Italian were not so good as last year; although there were 99 less candidates than in 1923, there were 53 more failures this year. An important part of the Oral Test is the taking down of a passage dictated in the foreign language by the examiner, and in the past this has been a source of great weakness with many candidates. It is gratifying to be able to state that the examiners now report a very great improvement in this branch of the examination.

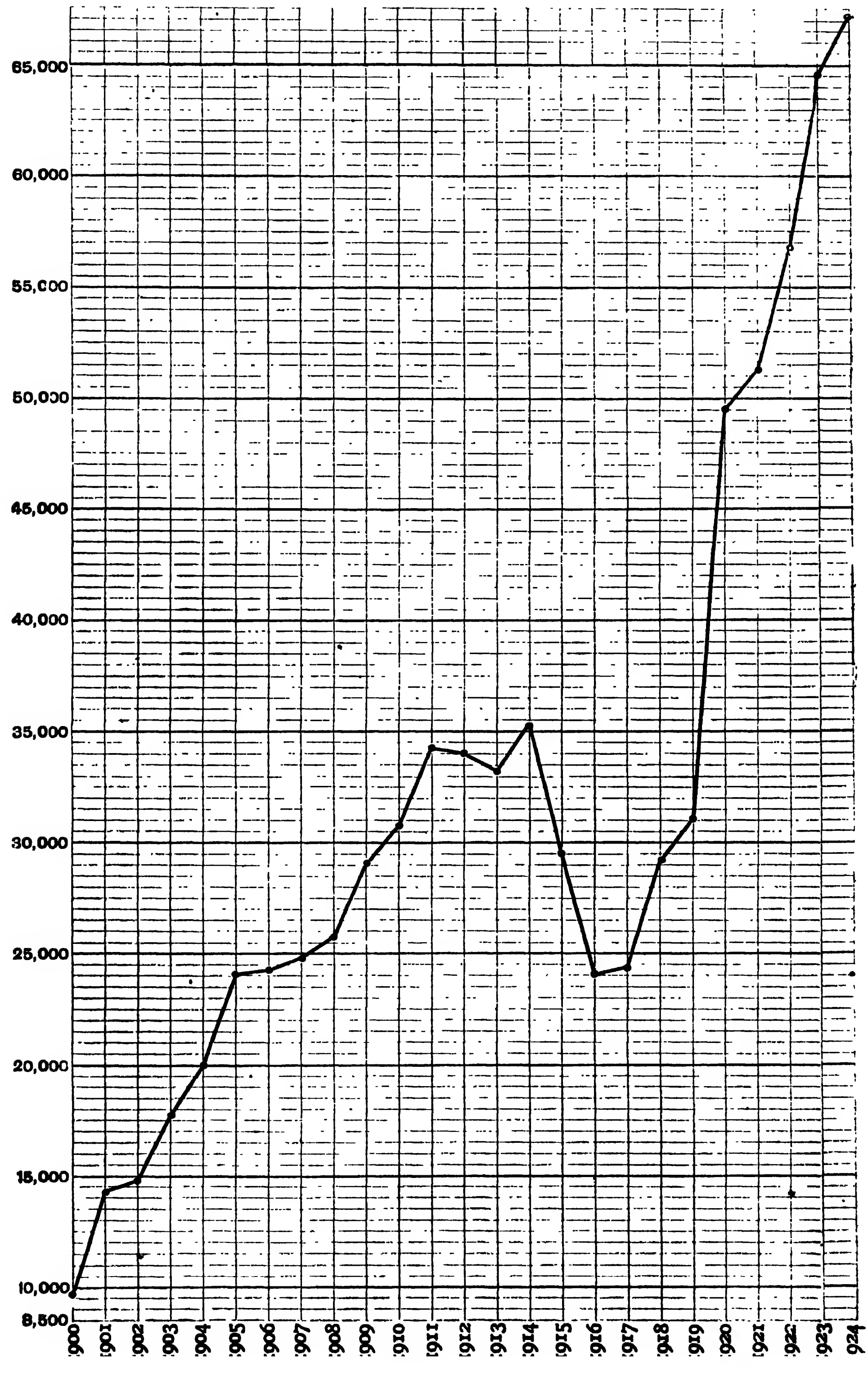
ORAL EXAMINATIONS HELD DURING 1924.

Subject.	No. of Examination Centres.	No. of Examiners	No. of Candidates examined.	Passed with Distinction.	Passed.	Failed.
French	62	45	626	95	350	181
German	9	8	55	18	32	5
Spanish	18	15	96	20	65	11
Italian	4	4	18	8	10	—
	93	72	795	141	457	197

Details of the 1924 Examinations.

Subjects.	Stage III.—Advanced.				Stage II.—Intermediate.				Stage I.—Elementary.			Total number of Papers worked in all Stages.	
	Papers worked.	1st-class Certificates.	2nd-class Certificates.	Not passed.	Papers worked.	1st-class Certificates.	2nd-class Certificates.	Not passed.	Papers worked.	Passed.	Not passed.	1924	1923
Arithmetic	291	30	111	150	1,760	296	883	581	5,414	3,810	1,604	7,465	6,568
English	337	20	160	157	1,505	93	984	428	3,848	2,127	1,721	5,690	4,997
Book-keeping	3,440	422	1,494	1,524	7,375	866	4,541	1,968	9,594	5,890	3,704	20,409	20,610
Economic Geography	49	4	31	14	158	—	94	64	292	185	107	499	502
Shorthand	1,273	88	180	1,005	6,132	1,111	2,676	2,345	6,113	4,493	1,620	13,518	12,679
Typewriting	596	120	360	116	2,356	1,055	1,070	231	3,524	2,482	1,042	6,476	5,678
Economic and Social History ..	17	1	15	1	44	5	22	17	85	49	36	146	48
Economic Theory	150	17	90	43	228	12	155	61	—	—	—	378	355
Précis-writing	46	6	30	10	55	10	31	14	—	—	—	101	113
Commercial Correspondence and Business Knowledge ..	101	8	42	51	951	72	708	171	2,944	1,931	1,013	3,996	4,240
Commercial Law	162	45	80	37	271	71	159	41	—	—	—	433	581
Company Law	111	20	64	27	197	67	123	7	—	—	—	308	415
Accounting	623	70	284	269	—	—	—	—	—	—	—	623	742
Banking	31	5	10	16	—	—	—	—	—	—	—	31	37
Foreign Exchange	11	1	8	2	14	4	7	3	—	—	—	25	—
Theory and Practice of Commerce	182	23	90	69	479	24	293	162	379	254	125	1,040	768
Railway Law and Practice	58	11	32	15	—	—	—	—	—	—	—	58	107
Railway Economics	29	6	15	8	—	—	—	—	—	—	—	29	35
Shipping Law and Practice	33	5	15	13	—	—	—	—	—	—	—	33	21
Stock Exchange Law and Practice	23	3	13	7	22	8	8	6	—	—	—	45	—
Insurance Law and Practice	19	4	13	2	—	—	—	—	—	—	—	19	25
Advertising and Salesmanship	41	7	28	6	—	—	—	—	—	—	—	41	—
French	612	77	293	242	1,799	119	1,020	660	2,397	1,879	518	4,808	4,812
German	58	24	21	13	136	18	73	45	141	80	61	335	340
Italian	17	2	13	2	25	1	17	7	56	36	20	98	107
Spanish	99	11	67	21	242	27	183	32	297	244	53	638	711
Russian	3	1	2	—	7	4	2	1	12	9	3	22	27
Danish and Norwegian ..	2	1	—	1	8	5	3	—	—	—	—	10	—
Dutch	—	—	—	—	4	—	2	2	—	—	—	4	—
Swedish	—	—	—	—	4	1	2	1	—	—	—	4	—
Totals, 1924	8,414	1,032	3,561	3,821	23,772	3,869	13,056	6,847	35,096	23,469	11,627	67,282	—
„ 1923	8,688	1,015	4,286	3,387	23,132	3,185	12,873	7,074	32,698	20,868	11,830	—	64,518

DIAGRAM SHOWING NUMBER OF PAPERS WORKED IN THE EXAMINATIONS, 1900-1924.



Commercial Knowledge Certificates.

The increase, noted in last year's report in the number of Candidates entered from Higher Elementary Schools, and also the new Central Day Schools set up under various Education Authorities, has been well maintained. Most of these Candidates take a group of subjects qualifying for the Certificate in Elementary Commercial Knowledge. To gain this special Certificate Candidates must pass in Arithmetic, Book-keeping, English and one other subject within three consecutive years, but it is satisfactory to find that many pupils from Day Schools pass in the necessary subjects in one year. In view of the fact that a fairly high standard is maintained in the Elementary Stage (it is by no means a first year's examination) the results at these Schools give evidence of really excellent preparation.

The thanks of the Council are once more accorded to the Court of the Clothworkers' Company, who have generously renewed their grant of £40, towards providing medals in all the subjects of examination where the work of candidates attains a sufficiently high standard. There is no doubt that there is very keen competition for these medals, and that they have done much to maintain or raise the level of excellence in the papers worked.

The Examination Syllabus for 1925* has been issued. In it will be found the fullest possible information about the examinations, a syllabus of each stage of each subject, and list of centres. The papers set in 1924 have been reprinted in six pamphlets. Each pamphlet contains in addition to the papers of each stage, the syllabuses of the subjects in the pamphlet and the Examiners' reports on the papers worked. Both teachers and students are strongly advised to study not only the syllabuses, but also the remarks of the various examiners on the results of last year. It will be found that these contain many valuable and helpful suggestions, and the work of the candidates year after year shows that far too little attention is paid to them.

The regulations for the Oral Examinations in Modern Languages are also given at full length in the syllabus.

* The price of the Syllabus for 1925 is 4*d*., post free. Copies can be obtained on application to the Examinations Officer, Royal Society of Arts, Adelphi, London W.C.(2). The price of the pamphlets containing the 1924 papers is 4*d*. each, post free. Particulars of these may be obtained as above.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

COLLOID CHEMISTRY.

By Eric K. Rideal, M.B.E., Ph.D., D.Sc., F.I.C.

Lecture I.—*Delivered January 21st*, 1924.

The growth of what is generally termed civilisation is dependent in great measure on the increase in knowledge of the properties and uses of the materials and forces placed at our disposal in the universe. The periods of development may roughly be divided into five: the prehistoric, stone, bronze, iron and the present. If we examine the complicated mosaic which constitutes our age we note that the subject of colloidal phenomena and properties of colloids is becoming increasingly important. It would take too long a time to enumerate the various directions into which the subject matter intrudes, but its significance will be understood when we remember that the animal and vegetable and many mineral products, which in major part form our bodies, clothes and food and fuel, are endowed with and operate in great measure under the influence of those forces which are the *raison d'être* of colloidal phenomena.

The term colloid was introduced in 1861 by Thomas Graham, who distinguished colloidal substances from crystalline materials by the relatively rapid rate of diffusion of the latter class of substances, and he believed that the distinction between a crystalloid and a colloid was a fundamental one. It has, however, been shown that such a distinction is invalid since not only are many typical colloids, *e.g.*, colloidal gold and grass fibres, crystalline, but the rates of diffusion of all particles in a medium obey the same fundamental laws, whether those particles are sub-microscopic in size like the simple molecules or clearly visible even to the naked eye, such as coarse suspensions.

The fundamental property which imparts to colloidal systems their peculiar characteristics is exhibited most clearly by the property of adsorption. Adsorption is purely a surface effect, and conditions under which adsorption may occur are brought about whenever a fresh surface is produced. Such surfaces are necessarily interfaces, *e.g.*, at the boundary of a solid exposed to a gas or liquid; even in a high vacuum we must imagine the existence of a gas phase consisting of the vapour of the substance: thus with the possible variation in interfaces produced by the mutual contact of phases such as gas, immiscible liquids and immiscible solids, a great variety of colloidal systems may be produced. Since the chemical and physical properties of a system are, as it were, in competition with the properties of the interfaces of the system, it is necessary, if these latter are to be dominant, so to prepare the system that it shall contain a large specific surface or that one phase shall be extremely subdivided; such division is readily accomplished by dispersion. When we enquire further as to the cause of the property of adsorption exhibited by interfaces we find that we must attribute to liquid and solid surfaces a certain surface energy. In the case of liquids it is a relatively simple matter both to demonstrate and measure this surface energy. That soap bubbles, small drops of liquid, or, as in Plateau's beautiful experiments, a mass of oil suspended in water, take up, when in a position of equilibrium, a perfectly spherical form indicates that some force is operative in causing both drops and bubbles to present the minimum of surface compatible with their volume. It is also clearly evident in a qualitative manner at least that a molecule in the interior of a liquid is attracted by its neighbours by the forces of cohesion equally in all directions, whilst a molecule on the surface is only attracted downwards and laterally; thus the surface energy of a liquid is closely related to the forces of molecular cohesion.

Again we find out readily by experiment that bubbles have to be blown; work is done when we expand the film of the bubble just as we must do work when we blow up a football or balloon. A simple mathematical calculation shows us that there exists an intimate relationship between the pressure of air inside the bubble and the surface energy of the material of the film; the excess pressure is directly proportional to the surface energy and inversely proportional to the radius. By this and several other methods it is possible to measure with a high degree of accuracy the surface energy of liquids; these vary in a marked manner from liquid to liquid as indicated by the following figures.

Substance.	°C.	σ in ergs. per cm^2.
H_2	—252	2
Ar	—186.1	12.7
Br_2	+20	38.0
NH_3	—29	41.8
C_8H_{14}	20	17.4
CCl_3H	20	26.3
C_6H_6	20	28.2
$C_6H_5NH_2$	20	43.8
H_2O	0	75.7
K Br	734	88.8
Li Cl	608	140
K	58	360
Hg	15	436
Ag	1060	750
Fe	1200	ca. 1000
Pt	1770	1500–2000

Applying a reasoning similar to the above to the case of small drops of liquid we find that the vapour pressure above a small drop will be greater than that above a large drop, a matter of importance. we may note in passing, in the formation of mists and fogs.

Since liquids exert a surface tension it is only reasonable to assume that solids also are endowed with this characteristic property, which is the resultant of the unbalanced forces of molecular cohesion.

Unfortunately, a solid is not readily deformed by the surface forces, the forces of crystallisation being so much stronger; thus direct methods of measuring the surface energy of solids are not available, we are forced back to indirect methods of computation. On the assumption that small crystals behave in a manner similar to small drops of a mobile liquid, an estimation of the surface tension of a solid may be computed as Pawlow has shown from the melting point, or as investigated by Ostwald and Hulett from the solubility of such small crystals. The computed values determined in this way gave a value for calcium sulphate of 1,050 ergs. per sq. cm.; more recent experiments by Dunden and Mack have reduced this value to 370 ergs. per sq. cm. It is, however, very doubtful whether the basic assumption of identity in behaviour of a small crystal and a drop of liquid is correct, thus casting doubt upon the validity of these values.

The very fact, however, that a certain amount of energy must be expended in breaking a crystal indicates at least the existence of powerful forces at solid surfaces; that these forces persist after cleavage is made clear by the fact that clean sheets of mica, of optical glass and of smooth clean metals, can frequently be joined together again by the exertion of but a slight pressure to form a solid, showing no discontinuity at the original plane of separation.

When considering the part played by this surface energy in adsorption it must not be forgotten that the free energy of the cohesive forces, and thus the surface tension, varies in magnitude with the temperature. In general on expansion of a surface the surface cools; the total surface energy being related to the free surface energy or surface tension by the relationship.

$$u = \sigma - \theta \left[\frac{\delta \sigma}{\delta \theta} \right]$$

Over a wide range in temperature the temperature coefficient of the surface tension $-\frac{\delta\sigma}{\delta\theta}$ is constant, and σ is found to decrease with the temperature. Thus we should expect that the adsorption at interfaces would decrease with elevation of the temperature, and this actually occurs.

Owing to the existence of such surface energy, substances, unless otherwise constrained, will attempt to lower the free energy associated with the exposure of the interface: this, as we have seen, can be accomplished by acquiring a spherical shape. We can likewise imagine the coalescence of small spheres to form a large one with less specific surface. The surface energy may also be lowered by adsorption; thus the addition of fatty acids to water lowers the air liquid surface tension and in consequence the fatty acids will tend to collect at the air liquid interface, but a limit will be set to the amount there collected by the opposing osmotic forces created by the difference in concentration between the bulk of the solution and the surface layer. Gibbs showed that there existed a close relationship between the excess concentration at the surface per sq. cm. (Σ) over the bulk concentration(c) and the effect of the solute on the surface tension of the solution is usually expressed in the form

$$\Sigma = -\frac{\delta d}{\delta \mu}$$

where μ is the activity or chemical potential of the ubstance in the solution. Substances which would cause an increase in the surface energy will conversely tend to leave the surface layer and move into the bulk of the solution.

In the same way a solid surface will adsorb gases, liquids or liquids and dissolved solutes if a diminution in the free surface energy of the system may be effected by such adsorption.

As we have already had occasion to note, the forces of adsorption are intimately connected with the forces of cohesion, and are thus chemical in their nature; we would thus expect that all substances are not adsorbed with equal facility. There is a preferential adsorption for those substances in which the reaction of adsorption, proceeds with the greatest decrease in the free energy of the system. Thus if a silica jel be exposed to a mixture of hydrogen and benzene vapour, the benzene will be more readily adsorbed than the hydrogen. Similarly carbon monoxide is more readily adsorbed by metals than hydrogen, but both gases are actually adsorbed. Thus the adsorption of hydrogen, carbon monoxide and of a 90 : 10 hydrogen carbon monoxide mixture by 1.45 c.c. of clean copper made to expose a large area by special preparation yielded the following results:

Vol. of CO adsorbed, 0.99 c.c.
Vol. of H_2 adsorbed, 0.12 c.c.
Vol. of mixture adsorbed, 0.23 c.c.
Composition of mixture, CO : H_2 16 : 1

In solutions as well we find that selective adsorption occurs not only at the air liquid interface, but also at interfaces produced on the insertion of a solid in the liquid. Thus the fatty acids, various colouring matters and many salts are preferentially adsorbed by charcoal from aqueous solutions. In all cases, however, both solvent and solute are adsorbed. This property of adsorption from solution is made use of in the many processes of purification and decolorisation. In the case of solids it is evident that we cannot test the Gibbs equation expressing the relationship between the decrease in the surface energy of the solid liquid or solid gas interface, and the concentration in the adsorbing layer. So many attempts have been made to obtain a relationship between the concentration or activity of the material undergoing selective adsorption in the liquid or the gas phase and the amount adsorbed.

The most general formula is that proposed by Freundlich in which the relationship

between the amount adsorbed x and the concentration of the solute c, or the pressure of the gas is expressed by means of an equation of the type

$$x = ac^{\frac{1}{n}} \text{ or } x = ap^{\frac{1}{n}}$$

containing two constants a and n.

As typical of the values obtained the following may be cited:

(a) *Gases.*	Charcoal. Adsorbing material. $\frac{1}{n}$	Glass. Adsorbing material. $\frac{1}{n}$
CO_2	0,394	0,66
$N.H_3$	0,437	0.53
SO_2	0,324	0,28

(b) *Aqueous Solutions.*	+n
Iodine on starch	5
Methylene blue on cellulose	2
Indigo carmine on silk ..	2
Alizarine on chromic oxide..	3
Iodine in alcohol on charcoal	4
Potassium chloride on charcoal	1

Although the equation of Freundlich represents the results fairly closely it is by no means accurate, for, as we have noted, in a gas mixture or a solution all constituents are adsorbed, the more reactive being more readily adsorbed. In some cases the phenomenon of negative adsorption is noted; the strength of a solution instead of being decreased by passage through a layer of charcoal or bauxite apparently becomes stronger since relatively more solvent than solute is adsorbed by the material. Thus dilute solutions of potassium nitrate exhibit the phenomenon of negative adsorption when exposed to a charcoal surface.

Again, there is a large volume of experimental evidence that the adsorption of many substances, especially what are termed non-polar substances, at high temperatures and low concentrations does not proceed indefinitely as the pressure or concentration is raised, as would be anticipated if Freundlich's equation held true ; but that a saturation maximum is attained as if the surface could hold so much adsorbed material and no more. . Langmuir has in fact shown that for such substances each atom of the adsorbent holds one atom of the adsorbate, and that the surface is saturated when it is covered with a film only one molecule deep.

The work of Hardy, Langmuir and N. K. Adam on surface tension of solutions and interfacial tensions between liquids, gives us a yet deeper insight into the mechanism of adsorption. If we bring two liquid surfaces together a certain decrease in the free energy will take place; thus if σA σB σAB be the surface energies of the two liquids and of the interface, then the decrease in free energy on bringing the surfaces together is given by the expression

$$W = \sigma A + \sigma B - \sigma AB$$

In the following table are summarised some of the values for this decrease in free energy when various liquids are brought into contact with water and mercury.

Substance.	*With Water.* *W.*	*With Mercury* *W.*
Petane	18.9	
Heptane	20.6	60.8
Octane	21.6	65.5
$C\,Cl_4$	24.0	74.8
Water	73	91.5
Ethyl iodide	—	110
Methyl iodide	—	110
Carbon disulphide	21	90
Ethyl ether	39.9	
Alcohols	47.8—51.8	
Organic Acids	46—50	
Ethyl esters	37—46	

It is evident that the decrease in free energy, when a liquid is brought into contact with the water or mercury, is most marked when the former contains a reactive group such as the hydroxyl, ether and carboxyl for water, the halide, sulphide and hydroxyl for mercury.

The action of the adsorptive forces is apparently to attack the adsorbed molecule by means of a specially reactive part of the molecule, and the molecule is orientated. Thus in the case of the fatty acids floating upon water we would expect from these considerations that they are orientated with the reactive carboxyl groups in the water and the paraffin chains emerging in a vertical plane from the water surface. If we count the number of molecules required just to saturate the surface of a known area of water, and measure also the molecular volume of the substance being adsorbed, we can evidently compute both the cross sectional area and the length of the molecule. This work, which was commenced by the late Lord Rayleigh and brought into prominence by I. Langmuir, is now being continued by Mr. Adam, and is of great interest owing to the fact that we can check the sizes of the molecules measured in this

way by the data obtained by Sir William Bragg and Mr. Shearer with the X-ray goniometer. As an example some of the data obtained by Langmuir and Adam for fatty acids and alcohol on water may be given :—

Substance.	*No. of atoms in chain.*	*Cross Section Area.*	*Cross Section Side.*	*Length*	*Length per carbon atom.*
Palmitic acid	16	21	4.6	24.0	1.5
Stearic acid	18	22	4.7	25.0	1.39
Cerotic Acid	26	25	5.0	31.0	1.20
Myricyl alcohol	31	27	5.2	41.0	1.37

It will be noted that the cross sectional area of each acid is practically constant and that the increase in length for each carbon atom added to the chain is likewise so. The most accurate surface tension data indicate a mean area of 20.1 A, whilst calculation from a knowledge of the molecular volume of a methylene group 17.8 cc., and the distance between the carbon atoms in a diamond from X-ray measurements of 1.52 A°, yields a value for the cross section of 19.3 A°. In a similar manner Adam found the area of the unit cell of benzene to be 23.8 A°, whilst Shearer and Bragg obtained 23.3 A°.

The orientated film of fatty acid floating on the surface of the water can be compressed or expanded by decreasing or increasing the area of the surface on which a known amount of fatty acid is present. A typical curve obtained in this way is shown in the following diagram:

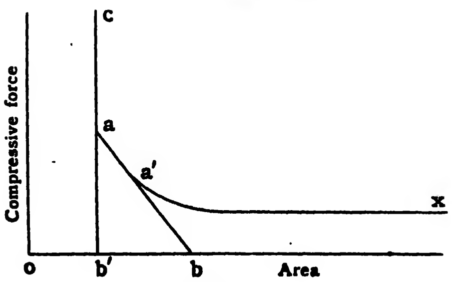


Fig. 1.

At high compressions in the region *ac* the curve is nearly parallel with the *y* axis, the molecules of fatty acid are packed as closely as possible and form the prolongation of the curve to *b'*, we obtain in *ob'* measure of the cross section of the paraffin chains which we have noted is 21 A°. From the slope of the curve *ac* it is evident that we can determine the compressibility of the film, and it is interesting to note (in confirmation of our hypothesis) that the compressibility of the fatty acid determined in this way agrees with the compressibility of a paraffin hydrocarbon. The curve *ca* on expansion shows a portion *aa'*, and the length of the line *ob* representing the area of this portion under zero compression is 25A°. Evidently there are two portions of the molecule which have different areas and different compressibilities. It is extremely probable that this second and larger portion is, as Adam has pointed out, the head of the molecule, *i.e.*, the area of the cross section of the carboxyl group is 25 A°. Adam in this way has measured the sizes of various heads of molecules; thus he finds the following values -COOH 25 A°, -NHCO the following values: -COOH 25 A°, $-NHCOH_2$ 25.5°A, and -CHBrCOOH from 26°A to 32.8°A, depending on the closeness of the packing.

We are thus dealing with a two-dimensional solid which can by suitable elevation of the temperature be turned into a two-dimensional liquid. The melting point of the acids in their two-dimensional layers is some 240°C lower than the same acids when in bulk. Under low pressures the two dimensional liquid expands the relationship between the area and the effective surface pressure, being indicated by the curve *xa'*. We are in this range dealing with a two-dimensional vapour and, as both Langmuir and Adam have shown, the ordinary Van der Waal law connecting pressure and volume, *i.e.*, $(P + \frac{a}{v^2})(v - b) = RT$, can be applied to this degraded two-dimensional gas.

The assumption that the Gibbs layer is only one molecule thick leads to very interesting conclusions. As we have noted from the Gibbs equation, the surface concentration should continue to alter as long as the addition of more solute affects the surface energy; consequently if we measure the critical concentration of the solute in solution or the partial pressure of the gas above a solution at which the surface energy is no longer affected we know that the Gibbs layer is either saturated with solute in cases of positive adsorption, or contains only pure solvent in cases of negative adsorption, and with the aid of Gibbs' equation we can calculate the quantity (per sq. cm.) present. Since we assume that the film is only one molecule deep, we are thus in a position to

measure the area and length of the molecules of substances which are soluble in solvents, whereas the method of Langmuir and Adam is only applicable to substances insoluble in the solvent.

The following molecular dimensions have been determined in this way:

	Area in A°.	Length.
On Mercury.		
Methyl acetate	27	—
Rubidium	12.4	4.46
Solvents with K Cl.		
Water	7	4
Ethyl alcohol	22	4.4

The information derived from a study of surface tension leads us to the conclusion that the molecules adsorbed at the surface of a liquid are orientated by attachment to the liquid at specific points, and that in general only one layer of such adsorbed molecules exists. There is little doubt that molecules are adsorbed on solid surfaces by similar forces and are similarly orientated. If the indirect measurements of the surface energy of solids are in any way reliable, their surface energies are much greater than for liquids, and it is to be anticipated that when one molecular layer of the adsorbate has become attached the new surface of adsorpate might still exert a by no means inconsiderable acsorbing power, permitting a bi-molecular film to be formed. Data on the adsorption of gases by solids indicate that, in all probability for those gases in which the intermolecular attraction is normally large as indicated by the $\frac{a}{v^2}$ term of the Van der Waals equation, multi-molecular layers on the adsorbed film do in fact exist; this is the case for gases at low temperatures, high pressures, and which possess highly polar molecules.

The conception that adsorption takes place at all interfaces and that the adsorbed layer consists of molecules orientated by attachment at certain specific points in the molecule, is at the present time finding many extremely important industrial applications.

In lubrication it has long been known that a pure hydrocarbon exerts but little lubricating power, but that a hydrocarbon can be converted into a relatively good lubricant by the addition of small quantities of fatty acids or the higher alcohols. This matter is receiving exhaustive examination by Hardy, who has shown that in all probability the fatty acid or alcohol is adsorbed by means of its polar group to the surface of the metal; and the hydrocarbon tail of the adsorbed film, which, as we have seen, possesses but little adhesional power for other hydrocarbon chains, is the real surface at which slip takes place: we are in fact protecting the metal surfaces with a strongly adhering oil film. The data on the decrease in free energy at mercury surfaces wetted with various liquids will doubtless reveal many other possible addition agents, such as the organic halides suitable for conversion of a hydrocarbon into a lubricant.

In the last series of Cantor lectures which I had the honour to give to you, I dealt at some length with the problem of catalysis and we saw there that the mechanism of heterogeneous catalysis was most readily explicable on the assumption that the reacting molecules were adsorbed by the catalyst surface in juxtaposition to one another and there reacted. During the last few years this subject has been receiving a great deal of attention and we now know of many cases in which adsorption does take place, but not any catalytic action. In such cases we have every reason to believe that the adsorbed molecules are oriented in the wrong way for mutual action, for by changing the catalyst so as to effect adsorption by another point of attachment to the molecule, reaction will proceed. Many organic substances, such as alcohols and formic acid, undergo different catalytic decomposition as the catalyst is varied, and in this case also we believe that the molecules of the adsorbate may be attached to the solid by more than one point of attachment, the relative strengths of these bonds being the determining factor in the subsequent molecular decomposition. It must be admitted that exact experimental proof of this hypothesis is still lacking, but the amount of indirect evidence in favour of such a hypothesis is rapidly increasing.

In biological investigations also the conception of orientated adsorption is proving fruitful in the better understanding of many complicated surface reactions.

The enzymes are the organic catalysts, and their catalytic activity must be interpreted in the light of our knowledge that the reactants are adsorbed on the surface of the enzyme. The numerous studies that have been made on the rate of enzyme action by Armstrong, Bayliss and others, have shown that such adsorption does in fact take place,

and that the reaction velocity is affected by the strength of such adsorption. Thus if the reactant is adsorbed strongly the enzyme surface will, over a great range of bulk concentration, possess a constant surface concentration, and the reaction velocity will be dependent merely on the quantity of enzyme present and independent of the concentration of the reactant. In some hydrolytic processes the products of the reaction are strongly adsorbed and the active surface of the enzyme gradually diminishes during the course of the reaction, due to such adsorption, and a species of negative autocatalysis is impressed upon the reaction velocity time curve.

Both the inorganic catalysts and the enzymes are highly susceptible to poisons. All other substances which are more strongly adsorbed than the reactants may be regarded as poisons, but some poisons are less virulent than others in that the adsorptive forces are weaker, permitting of their subsequent ready removal.

In the inorganic catalysts we have noted that in a few cases evidence is forthcoming that the adsorbate may become attached to the adsorbent by more than one point of attachment.

The organic enzymes appear to permit of such multi-point attachment. Although little is known at present as to the nature of enzymes, they appear to contain a number of reactive groups in each molecule, *e.g.* $-N.H_2$. $-OH$, $-COOH$. The enzyme particle likewise appears to be an aggregate of these complex molecules similar to the micellæ of a soap which we shall have occasion to discuss, and thus we may regard the surface of an enzyme as a regular chequer board with these active groups arranged in pattern on the surface. A reactant that can undergo reaction with the aid of the enzyme must attach itself to one or more of these reactive groups. Similar considerations can be applied to the action of germicides on micro-organism. In this case the presence of both acid and basic groups (acceptors) in the micro-organism can readily be demonstrated. In stapylococcus, for example, the basic acceptors are stronger than the acid ones, and the micro-organism is as a result more sensitive to acid germicides, With B. coli the reverse holds true. We thus see the beginning of selective action, which is the great characteristic of the more complicated organic structures met with in biology. If we imagine that the surface of the enzyme or of the bacterium contains two reactive groups or acceptors, *e.g.*, *a* $-NH_2$ and *a* $-COOH$ group in each molecule, at a distance apart depending on the number of carbon atoms between them, then a reactant which can react with both of these groups must contain its complementary reacting groups at approximately the same spacing in its molecule. Thus the hypothesis of multipoint adsorption leads us at once to a new interpretation of the old simile of the key and the lock.

SWEDISH HYDRO-ELECTRIC POWER RESOURCES.

According to the Report on the economic commercial and industrial situation of Sweden by the Commercial Secretary to H.M. Legation at Stockholm, it is estimated that the total energy available from waterfalls in Sweden amounts to about 6,000,000 h.p., of which some 4,500,000 h.p. is owned by municipalities and private concerns. Of this amount about 1,322,000 h.p. has already been developed and work is in progress for the harnessing of a further 90,000 h.p. In terms of hydro-electric energy the total utilisable resources are put at 42,625 million kilowatt hours per annum. It is stated, on expert authority, that this estimated energy could be more than doubled if the maximum fall of the entire volume of water in the country could be utilised. A recent estimate points out that about 40 per cent. of the Swedish rural districts are supplied with electricity by means of state, municipal, and private plants. Many plans are being studied for further extensions, among which may be mentioned the regulation of the water level of Lake Vänern. These plans will shortly be presented to Parliament, and, if approved, work will be commenced as soon as possible, but it is not anticipated that it can be completed before 1930.

It is expected that work will be commenced during 1924 in connexion with the harnessing of the Norrfors waterfall in Ume river, where some 100,000 h.p. is available. A comprehensive scheme is being prepared for enlarging the well-known Trollhätta power station, and operations are now in train for including the lower waterfall in the Göta river at Lilla Edet in the Trollhätta power net, which will yield an additional 33,000 h.p. The electrification of the main line railway from Stockholm to Gothenburg, work on which is now in full swing, will entail a large scheme for the reinforcement of existing power cables, the erection of new transformer stations, etc. The surplus revenue which the Royal Swedish Waterfall Board was able to hand over to the Treasury for 1923 working year amounted to Kr. 8,300,000, and the estimate for 1924 is put at Kr. 10,000,000.

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FRIDAY, OCTOBER 24, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. 2.

NOTICES.

OPENING OF THE 171st SESSION.

The Opening Meeting of the 171st Session will be held on Wednesday, November 5th, when an address will be delivered by Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., Chairman of the Council. The chair will be taken at 8 p.m.

COUNCIL.

A meeting of the Council was held on Monday, October 13th, Present: –

Mr. Alan A. Campbell Swinton, F.R.S., in the Chair; Sir Thomas J. Bennett, C.I.E.; Mr. A. Chaston Chapman, F.R.S.; Sir William Henry Davison, K.B.E., D.L., M.P.; Sir Archibald Denny, Bt., LL.D.; Mr. P. M. Evans, M.A., LL.D.; Sir Robert Hadfield, Bt., D.Sc., D.Met., F.R.S.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.; Sir Herbert Jackson, K.B.E., F.R.S.; Major Sir Humphrey Leggett, D.S.O., R.E.; Sir Philip Magnus, Bt.; Colonel Sir A. Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I.; Mr. Carmichael Thomas; Sir Frank Warner, K.B.E., and Sir Alfred Yarrow, Bt., M.Inst.C.E., F.R.S., with Mr. G. K. Menzies, M.A. (Secretary of the Society) and Mr. S. Digby, C.I.E. (Secretary of the Indian and Dominions and Colonies Sections).

The arrangements for the forthcoming session were considered and approved.

It was reported that a selection of textile designs from the Society's Exhibition at the Victoria and Albert Museum had been sent for further exhibition at Manchester, and that the glass designs had been forwarded to Stourbridge and Wordsley for exhibition at those places.

The sum of £200 has been voted by the Council to be used as prizes for encouraging candidates to take group certificates at the Society's examinations.

The Clothworkers' Company again promised £40 towards providing medals at the Society's Examinations.

A beautiful miniature of William Shipley, the founder of the Society, by William Hincks, was presented to the Society by Mr. Herbert Monckton, of Maidstone.

Subjects for the Peter Le Neve Foster and Fothergill prizes were considered.

Other formal business was transacted.

DOMINIONS AND COLONIES SECTION COMMITTEE.

Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc. (Chairman of the Council).
Lord Blyth (Chairman of the Committee).
Marquess of Aberdeen and Temair, K.T., G.C.M.G., G.C.V.O.
Colonel Hon. Sir James Allen, K.C.B., M.A. (High Commissioner for New Zealand).
Lord Askwith, K.C.B., K.C., D.C.L.
Sir Charles H. Bedford, LL.D., D.Sc.
Byron Brenan, C.M.G.
Sir William H. Clark, K.C.S.I., C.M.G.
Sir Dugald Clerk, K.B.E., D.Sc., F.R.S.
Hon. Sir John A. Cockburn, K.C.M.G.
Hon. Sir Timothy Augustine Coghlan, K.C.M.G., I.S.O. (Agent-General for New South Wales).
Hon. H. P. Colebatch (Agent-General for Western Australia).
Hon. Sir James Daniel Connolly.
Sir Joseph Cook, P.C., G.C.M.G. (High Commissioner for Australia).
Sir Edward Davson.
Edward Dent, M.A.
Hon. G. Fairbairn (Agent-General for Victoria).
W. L. Griffith.
Rear-Admiral James de Courcy Hamilton, M.V.O.
P. J. Hannon.
Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.
Hon. J. Huxham (Agent-General for Queensland).
Viscount Inchcape, G.C.S.I., G.C.M.G., K.C.I.E.
Hon. Peter C. Larkin (High Commissioner for Canada).
Major Sir Humphrey Leggett, D.S.O., R.E.
Hon. Sir Edward Lucas (Agent-General for South Australia).
Rt. Hon. Sir Frederick Lugard, G.C.M.G., C.B., D.S.O., D.C.L.

Sir Charles Campbell McLeod.
Sir Charles Metcalfe, Bt.
Sir Robert W. Perks, Bt.
Lieut.-Colonel Sir Thomas Bilbe Robinson, G.B.E., K.C.M.G.
M. L. Shepherd, I.S.O.
Lieut.-Colonel R. E. Snowden (Agent-General for Tasmania).
Major H. Blake Taylor, C.B.E.
Carmichael Thomas.
F. C. Wade, K.C. (Agent-General for British Columbia).
Hon. Sir Edgar Walton, K.C.M.G. (High Commissioner for South Africa).
George Wilson, C.B.
S. Digby, C.I.E. (Secretary).

INDIAN SECTION COMMITTEE.

Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc. (Chairman of the Council).
Sir Edward Albert Gait, K.C.S.I., C.I.E., Ph.D. (Chairman of the Committee).
Sir Charles H. Armstrong.
Sir Arundel T. Arundel, K.C.S.I.
Lord Askwith, K.C.B., K.C., D.C.L.
Sir George Stapylton Barnes, K.C.B., K.C.S.I.
Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.
Sir Steuart Colvin Bayley, G.C.S.I., C.I.E.
Sir Charles H. Bedford, LL.D., D.Sc.
Sir Thomas Jewell Bennett, C.I.E.
Sir M. M. Bhownaggree, K.C.I.E.
Sir George C. Buchanan, K.C.I.E., M.Inst. C.E.
Cecil L. Burns.
Sir Valentine Chirol.
Sir William H. Clark, K.C.S.I., C.M.G.
William Coldstream, B.A.
Laurence Currie, M.A., J.P.
Marquess Curzon of Kedleston, K.G., P.C., G.C.S.I., G.C.I.E.
Colonel Arthur Hills Gleadowe-Newcomen, C.I.E., V.D.
Sir Krishna Govinda Gupta, K.C.S.I.
Sir Claude H. A. Hill, K.C.S.I., C.I.E.
Colonel Sir Thomas Hungerford Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc.
Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S.
Viscount Inchcape, G.C.M.G., K.C.S.I., K.C.I.E.
Sir Louis James Kershaw, K.C.S.I., C.I.E.
Sir Henry Ledgard.
H. A. F. Lindsay, C.B.E., I.C.S.
Major-General Beresford Lovett, C.B., C.S.I.
Sir Charles Campbell McLeod.
Colonel Sir A. Henry McMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I.
Thomas McMorran.
Sir John Ontario Miller, K.C.S.I.
Lord Montagu of Beaulieu, K.C.I.E., C.S.I.
N. C. Sen, O.B.E.
Brigadier-General Sir Percy M. Sykes, K.C.I.E., C.B., C.M.G.
Major H. Blake Taylor, C.B.E.
Colonel Sir Richard C. Temple, Bt., C.B., C.I.E.
Carmichael Thomas.
J. A. Voelcker, M.A., Ph.D., F.I.C.
N. N. Wadia, C.I.E.
Sir Frank Warner, K.B.E.
Colonel Sir Charles Edward Yate, Bt., C.S.I., C.M.G.
S. Digby, C.I.E. (Secretary).

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

COLLOID CHEMISTRY.

By Eric K. Rideal, M.B.E., Ph.D., D.Sc., F.I.C.

Lecture II.—*Delivered January 28th*, 1924.

In this lecture I should like to devote the time to the consideration of the suspension colloids in which a solid phase is finely dispersed in either a liquid or gaseous dispersion medium forming sols and smokes respectively, and we shall have occasion to note how different are the properties of such a disperse system from the solid material one, due, as we have already noted in our last lecture, to the operation of surface forces. A solid disperse phase may evidently be prepared in two ways either by growth from molecules in solution or by dispersion of a bulky solid. In industrial practice both these methods are adopted for preparing colloidal sols and we must consider the various factors governing the formation of disperse systems by these means.

Methods of condensation.

If a solution of salt be undercooled the solution will become relatively supersaturated owing to the fact that salt is more soluble in hot than in cold water. The formation and growth of crystals in such a supersaturated solution are in reality two independent processes. For a crystal to start growing it is necessary as we have already noted for a nucleus to be present, the solubility of which is less than concentration of the solution; once a nucleus is formed it proceeds to grow by the diffusion of the molecules of the various minute crystal faces. Gibbs has pointed out that the various crystal faces may possess different surface energies and thus those faces which possess the smallest interfacial surface energy will be most stable. If the conditions are favourable to very rapid growth, however,

not only will faces appear which possess higher surface energies but the molecules may actually become attached to the surface in positions which are not in the regular crystalline space lattice and we thus build up a partly regular and partly irregular molecular structure. Such a particle will possess a high superficial surface energy. On warming the energy will gradually decrease since the thermal oscillations of the attached molecules when sufficiently vigorous will permit of their entering their proper position in the crystalline space lattice; such an operation, known as sintering, is frequently made use of in the baking of materials such as are employed for brick and pottery manufacture and in the production of solid metals from powders, as in the case of tungsten.

A sol consists of a highly dispersed solid; thus in order to prevent the growth of a relatively few large crystals it is evidently necessary to ensure the simultaneous formation of a large number of nuclei which must grow extremely rapidly. These principles have been developed in detail by von Weimarn, who has shown that we may obtain materials in either the crystalline or colloidal state by alteration of what is termed the dispersion coefficient; the dispersion coefficient being defined by the equation

$$\delta = \frac{C}{S}$$

where C is the degree of supersaturation or equivalent concentration in the solution and S the solubility. A high dispersion coefficient ensures the formation of a small grain or potential colloid. I might quote the result of one of von Weimarn's numerous experiments on the interaction of barium sulphocyanide and manganous sulphate in aqueous solution resulting in the formation of barium sulphate usually obtained in the crystalline condition.

Dispersion Coefficient.	Nature of product.
0—3	Several years to crystallise.
3—48	A fine crystalline deposit obtained after a period of a month to a week.
48—88,000	First granular, then curdy, then gelatinous.
88,000—200,000	A viscous jelly.

This method of preparation is generally employed for the preparation of metal sols since, owing to the almost vanishingly small value of $\frac{C}{S}$, the solubility of the metal in the dispersion medium, large values of δ favourable to the formation of a system of high dispersity are rapidly obtained.

Methods of dispersion.

Mechanical dispersion may be accomplished by processes of heating, hammering and trituration or in the electrical arc. All these methods are employed for the preparation of sols, the electric arc process being most general in the laboratory, whilst the various colloid mills are used in industrial work.

Such methods of mechanical dispersion, however, do not in themselves, as would be expected, lead to the formation of stable sols, a point which we shall see is of great importance not only in the technical but the theoretical development of colloidal chemistry. The observations of many investigators, commencing with Leeuwenhoek in the seventeenth century, of Robert Brown, Wiener, Jevons and Gouy, in the nineteenth, and the more recent investigations by Zsigmondy, Perrin and Einstein, have shown that the small particles of the solid are in continuous agitation moving across the field of a powerful microscope or as a point of light in the ultramicroscope in a curious tremulous zigzag fashion.

Such motion, the Brownian agitation, has been shown to be due to molecular bombardment; we are in fact observing the movements of particularly large molecules under the impacts constituting the molecular thermal agitation. Although the assemblage of molecules forming the colloidal particle may have an apparent molecular weight of over 50,000 tons, yet it moves in the dispersion medium exactly the same in type and extent of its motion as can be predicted for a gigantic molecule. Its movements are naturally not so lively as the small molecules, since the sudden impact of a molecule bombarding its side would have but little effect on its motion, but every now and again a sufficient number of molecules of the circumambient dispersion medium hit one side to give the particle a movement in that particular direction, thus giving rise to the

characteristic zigzag motion previously alluded to. In this connexion it is interesting to note that Perrin has shown that the probability of a sufficient number of air molecules hitting one side of a brick weighing a kilogram, to give the brick a perceptible movement, occurs once in $10^{10^{10}}$ years.

The sol particles behave like large molecules in respect to the movements of thermal agitation and rotation; we should thus expect that chance of collisions between particles would occur with some frequency and that under the influence of the surface forces coalescence would occur and the sol would rapidly flocculate or precipitate. This, however, is, in general, not the case; sols are frequently extremely stable and may be preserved for a number of years. Faraday's original colloidal gold may yet be observed in the Laboratory at the Royal Institution. There are certain factors which render the dispersion stable; the two important factors making for stability of sols are the electric charge and the interfacial surface tension. These two factors are to some extent related since the charge on a surface affects its surface tension, but the exact relationship between these two factors, if any such exists, has not yet been developed in detail.

Colloidal sols to be stable must possess an electric charge; it is found that certain sols such as the colloidal metals, colloidal sulphides, gums and oils possess in general a negative charge, whilst hydroxides and oxides of the metals, many dyes such as Bismarck brown, methylene blue are positively charged.

The production of an electric charge on a colloidal particle may result in two different ways; if an electrolyte be present in the dispersion medium it will be adsorbed at the interface. In general the adsorptive power of the interface is not identical for anion and cation of the electrolyte; there will consequently be a preferential adsorption of one ion, *e.g.*, the anion for colloidal sulphides and oils, the cation for methylene blue.

Evidently the preferential adsorption of an ion produces an interfacial electrification with the result that the ions of opposite sign are held to the outside of the electrified surface producing an electrical double layer, likewise we must note that the ions of opposite sign at the outside of the double layer are attempting to pull off the preferentially adsorbed ion; thus the preferentially adsorbed ion is not adsorbed to its equilibrium concentration, whilst the less adsorbable ion is adsorbed in excess of the concentration at which equilibrium would be attained in the absence of such electrical effects. Again many colloidal sols acquire an electric charge by surface ionisation; thus in the formation of colloidal ferric hydroxide from ferric chloride by a process of dialysis we have every reason to believe that the particle of the sol is constituted of ferric hydroxide containing a small quantity of ferric chloride.

$$\left\{ Fe(OH)_3 \right\}_n \quad FeCl_3$$

which on dispersion in water undergoes partial ionisation to

$$\left\{ Fe(OH)_3 \right\}_n Fe\overset{+}{Cl_2} + \overset{|}{Cl}$$

the particle thus acquiring a positive charge.

The electric charge on a particle causes the particle to acquire a potential with respect to its environment. If the particle be spherical at radius r and had a charge e its potential will be $\frac{e}{kr}$ where k is the specific inductive capacity of the material. The stability of a colloid is governed by this potential—the electro-kinetic potential. For water a sol is stable if the potential exceeds some 35 millivolts, and it may rise as high as 70 millivolts. To prepare a sol from an amorphous precipitate it is evident that we must give the particles a charge; this can be done by adding to the solution containing the precipitate a small quantity of an electrolyte of which one ion is readily adsorbed; this is termed ionic peptisation. Colloidal silver iodide may be prepared from precipitated silver iodide by the addition of small quantities of either silver nitrate or sodium iodide, as the solid readily adsorbs both silver and iodine ions; we can in this way form either a positive or negative colloidal solution of silver iodide.

To stabilise small particles we may, as we have seen, lower the interfacial surface tension between the particle and the dispersion medium; this can be accomplished by adding to the solution some material which is more strongly adsorbed by the surface than the dispersion medium. Zsigmondy noted that gelatine, soaps, gums, hæmoglobin, lysalbic and protalbic acids functioned as protecting agents, *i.e.*, in-

creased the stability of the particle by such preferential adsorption. More recent experiments, however, have indicated that the problem of protection is somewhat more complex. Thus colloidal gold is usually negatively charged; if we add to the gold solution some gelatine, protection will ensue, but gelatine can act both as an acid and a base, being in fact an amphoteric electrolyte. Thus on the addition of gelatine on the basic side the gelatine will be negatively charged and the protected colloid will be negative. If, on the other hand, we add gelatine on the acid side of what is termed the isoelectric point, the gelatine will be positively charged; this will adhere to the gold particles, discharge them and precipitate the gold, but on the addition of larger quantities the gold will be repeptised and we shall obtain a stable positively charged protected gold sol.

We have noted that bringing oppositely charged colloids together results first in adsorption, resulting in a lowering of the electro-kinetic potential and consequent precipitation. On further addition the precipitated colloid may adsorb more of the colloid and become stabilised again but of opposite sign.

Precipitation may likewise be produced by the addition of electrolyte containing easily adsorbable ions of opposite sign. Since precipitation is produced by neutralisation of the electric charge very much smaller quantities of trivalent ions, *e.g.*, aluminium, than of divalent or monavalent ions will be required. The adsorption of trivalent ions is likewise more pronounced than those of lesser valency, consequently, but minute amounts of trivalent ions are required to effect precipitation some thirty two times the concentration of divalent ions and about one thousand times the concentration of monovalent ions being required. The adsorptive power of a colloid for an ion depends, as we have noted, not only on the electrical charges of the two but also on the surface forces which are chemical in character, and thus we find that the monovalent organic ions of the dyestuffs or aniline and its homologues are much more effective than the simpler inorganic ions. The following data indicate that although the same electrical equivalent amounts are adsorbed when precipitation results, yet the concentration of electrolytes in the bulk solution may be very different.

Precipitation of colloidal $Al(OH)_3$

Anion.	Bulk concentration millemols per litre.	Adsorbed quantity in mille-equivalents.
Salicylate	8	0·30
Picrate	4	0·18
Osculate	0·36	0·36
Ferrycyanide	0·10	0·27
Ferrocyanide	0·08	0·29

In general both ions are adsorbed and we should expect that the concentration of a cation required to precipitate a negatively charged colloid would vary with the nature of the anion; a feebly absorbed anion will permit of a relatively dilute electrolyte affecting coagulation. The following represent what are termed the liminal coagulating concentrations of salts possessing a common precipitatory ion for a positive and negative colloid :

Colloid.	Sign.	Liminal concentrations in milleequivalents per litre.	
Pt	—	$\overset{+}{Na}Cl$ 2·5	$\overset{+}{Na}OH$ 130
$Fe(OH)_3$	+	$H\bar{Cl}$ 4·00	$Ba\bar{Cl}_2$ 9·64

Evidently the OH is more strongly adsorbed than the $\bar{Cl}$ by platinum, necessitating a higher concentration of the precipitatory $\overset{+}{Na}$ when present as caustic soda, whilst in the case of $Fe(OH)_3$ the Ba is more strongly adsorbed than the $\dot{H}$ by electropositive ferric hydroxide.

The stabilisation of colloids by the addition of protective colloids has received extended application; thus we find colloidal platinum employed for catalytic hydrogenation is always protected by means of gum arabic or lysalbic acid, whilst the colloidal metals and other sols employed for therapeutic purposes must be protected from precipitation of the salts present in the blood. Evidently the factors to be considered in the preparation of such substances are enhancement of stability against precipitation with suitable adjustment of their toxic action. Such action appears to be dependent, at any rate in some cases, on disintegration of the particle and subsequent reaction of the agent in a molecular or ionic form; in other cases on the adsorption of the colloid by surfaces where they can promote catalytic changes, a case of bringing the catalyst to the reactant. Over protection will evidently exert a depressing effect on the activity of such colloidal reagents, whilst the preparation of sols of insufficient dispersity is likewise to be avoided from similar considerations.

The existence of an electrokinetic potential between a particle and the dispersion medium gives rise to the phenomenon of electric cataphoresis and electric endosmose. If a couple of electrodes be placed in a colloidal solution and a difference of potential be applied, the particles, if positively charged will wander to the cathode and the mobility of the particles can readily be calculated with the aid of Stokes' law. On discharge of the particle by the addition of electrolytes the velocity which is governed by the magnitude of the charge will fall until at the isoelectric point no motion will be observed. Similarly, if the dispersion medium be brought in contact with a fixed porous diaphragm the presence of an electrokinetic potential can be demonstrated by the application of an applied electromotive force causing the liquid to move through the diaphragm. The following data obtained by Perrin indicate how the rates of electric endosmose may be caused to vary by altering the electrokinetic potentials by the addition of electrolytes :

Diaphragm material.	Electrolyte.	Diaphragm Charge.	Relative rate of endosmose.
Tungstic acid	water	+	0·26
	0·045 N H Cl	+	0·11
	0·2 N H Cl	+	0·03
	0·8 N H Cl	0	0
Gelatine	$\frac{N}{50}$ H Cl	+	2·2
	$\frac{N}{100}$ NaOH	—	3·5

Practical application of electric endosmose is made use of in the drying or dewatering of many colloidal materials such as peats and clays, and to the removal of sugar from beet, whilst we find application of electric cataphoresis to accelerate the penetration of colloidal tannic acid into hide materials and of various colloidal drugs into living tissues.

A third example of the technical application of protective measures is to be found in the recent development of colloidal fuels. Colloidal fuels consist essentially of a stable suspension of coal in a hydrocarbon oil. Although the oil solid interfacial tension may be relatively high, yet, owing to the high viscosity of the oil dispersion medium, the suspension may appear relatively stable. When, however, storage is contemplated it is necessary to add a fixateur, which is in fact a protective colloid. Tannin is said to prove efficacious, but many soft coals will undergo dispersion to a stable sol when heated to a high temperature in oil under pressure, there being evidently in the asphaltic constituent of the coal some effective peptising agent. Such suspensions may be rendered stable in this way for periods varying from a few days to several months.

Protective agents may also be regarded from a different point of view. It is evident that they are preferentially adsorbed and it is on this property, the preferential wetting of solids, that the practice of ore flotation is based. The operation of ore concentration as carried out in practice is relatively simple; thus galena can be separated from quartz by the addition of a little sulphuric acid and a drop of eucalpytus oil. On blowing air through the solution the galena is brought to the surface by the levitating action of the air bubbles which attach themselves only to this material. When the ore requires concentration for two substances such as galena and blende the problem becomes much more complicated since a selective attachment of the air bubbles to the two minerals must be obtained.

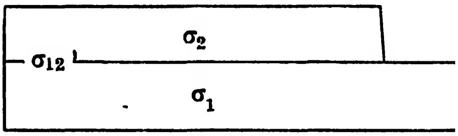

FIG. 2.

For a liquid of surface energy σ_2 to flow over a surface of a solid of surface energy σ_1 it is evident that there must be a diminution in the free surface energy or $\sigma_1 > \sigma_2 + \sigma_{12}$. Furthermore if the solid is already wetted by a liquid of surface energy σ_3 the liquid will displace the former if $\sigma_{13} > \sigma_{12} + \sigma_{23}$. As an example it may be mentioned that the surface energy of sulphur is about 26 ergs. per sq. cm., even if the energy of the sulphur liquid interface were zero it is evident that it can only be wet by liquids in which the surface energy is below 26, for

$$\sigma \frac{\text{sulphur}}{\text{air}} \quad \text{must be} \quad > \sigma \frac{\text{liquid}}{\text{air}}$$

Water will not wet sulphur, but if its surface energy is reduced by the addition of sodium oleate to below 26, wetting will occur.

Thus by coating the ore particles with a liquid which prevents them being wetted by the water or which will displace water from the surface small gas bubbles can adhere to them and float them to the surface. At the same time the quartz must not be so coated; hence if σ_q and σ_g be the surface energies of

the quartz and galena respectively, σ_e that of the flotation liquid, and σ_w that of water, we find that

$$\sigma_{gw} > \sigma_{gl} + \sigma_{ew}$$

but

$$\sigma_{qw} < \sigma_{ql} + \sigma_{ew}$$

Many examples of such preferential wetting of solid particles have been examined by Reinders and Hofmann; thus silver iodide in water if shaken up with amyl alcohol will be preferentially wetted by the alcohol and entirely leave the water. The displacement of air from the surface of leaves by a liquid is an important consideration in the preparation of insecticides and fungicides for plants. For an insecticide to wet a leaf it is evident that the following conditions must hold:

$$\sigma \text{ leaf air} > \sigma \text{ liquid air} + \sigma \text{ liquid leaf}$$

A low liquid air surface tension is evidently a desirable factor.

Solids may be dispersed in gaseous media as well as liquid producing smokes; these are very similar in their properties to the colloidal sols. Owing to the low viscosity of the medium the Brownian agitation is most marked, promoting rapid diffusion. The particles may, in fact, be so small as to be sensibly affected by the pressure of light, as demonstrated by Ehrenhaft by the photopheresis of dusts in the light of a powerful arc lamp. In the hot stars and the tails of comets a balance between the effects of gravitational attraction and the radiation pressure appears to be the important factor in determining their stability. Again the smokes are electrically charged and can be caused to exhibit electric cataphoresis under the influence of a potential gradient which forms the basis of the Lodge and Cottrell methods of removing industrially valuable products such as potassium salts from the gases of cement kilns, the treatment of metallurgical smokes from smelting works, the cleansing of blast furnace gas, the manufacture of lamp black, and the phosphoric acid, among many other industrial operations.

We have, in our previous lecture, noted that solid surfaces adsorb gases when the solid is dispersed in a fine state of subdivision; the adsorption increases with the increase in specific surface, and we must imagine powders as being surrounded with an adsorbed gas film; fine powders can frequently be poured like liquids and certain fumes like P_2O_5 are most difficult to wet; coalescence between the particles or wetting being prevented by the air cushion. Not all gases are adsorbed with great facility and the sensitiveness of the coherers employed in wireless may be altered very appreciably by an alteration in the nature of the gas film adsorbed and insulating the contacts from each other. The effect of bellows in causing a fire to burn with greater readiness may be due to the mechanical removal of adsorbed carbon dioxide as to the supply of fresh oxygen.

The increase in specific surface of a finely powdered solid or the conversion into a mist of a liquid fuel are obvious applications of the effect of increasing the specific surface on increasing the rate of a surface reaction. Dusts in air made from inflammable materials adsorb oxygen on their surface and may give rise to serious explosions such as witnessed with coal dust where a flame velocity of 2,000 ft. per second may be attained. The ignition of such dusts may be prevented by displacing the adsorbed oxygen film by water or carbon dioxide, but these affect the health of the underground workers, and more attention is paid to preventing the propagation of the explosive wave by the addition of shale or stone dust.

In conclusion I would like to comment on one of the most striking peculiarities of colloidal systems, namely, the curious and unusual colours which they present to the eye.

One of the most characteristic of structural colours is to be observed in the case of thin films, where, as shown by Newton, the interference of light of a particular wave-length reflected from the top and bottom surface of a thin film causes the appearance of the complementary colour. Many examples of such will occur to us in the soap bubble, oil films, tempered metals, agates and pearls.

The effect of scattering of light can be noted in the case of snow or triturated coloured salts; with increase in scattering power of the surface the lighter does the solid appear, a matter of importance in the paint industry. Very small particles, scatter, as shown by Rayleigh, blue light more than red light, thus the light transmitted through a layer of finely dispersed material will appear somewhat reddish, whilst the reflected light will appear somewhat bluish. A number of cases caused by such means have been collected

and examined by Bancroft; thus we find the blueness of blue eyes, of skim milk, of tobacco smoke, of the sky, and of the deep blue sea due to the scattering caused by small solid particles in a liquid or gaseous dispersion medium, whilst the blue of the kingfisher or the blue jay's feathers is caused by the scattering at the surfaces of minute air bubbles in the horny matter of the feathers. Hair goes white for a similar reason, but as far as I know no case of even acute worry has been able to reduce the bubble size in hair to cause it to turn blue.

The bright red sunsets observed during periods of volcanic activity must again be attributed to the transmission of white light denuded of the blue by scattering at the surface of dust particles.

The colours exhibited by colloidal metals are, however, the result of somewhat more complicated optical effects than mere scattering. In the case of gold the transmission of white light through a fine gold sol leads to a transmission of red light, whilst as the particles get larger the colour of the transmitted light becomes first violet and then blue, thus the small particles reflect green and blue light and the larger yellow and brown. Thin gold sheet transmits green light, thus we are dealing with resonance of light after absorption and re-emission of the metal. The work of Garnett, Gans, Neil and others has indicated that the problem becomes even more complicated when the shapes of the aggregates as affecting the scattering and the optical resonance are taken into consideration. The problem, however, is one of very marked industrial importance since the preparation of substances like enamels which consist of highly disperse sols of stannic or titanium oxides, of paints, of coloured glasses and the tints of various shades of dyes depend in a large measure on the optical effects produced by disperse systems.

NOTES ON BOOKS.

THE ECONOMIC DEVELOPMENT OF THE BRITISH OVERSEAS EMPIRE. By L. C. A. Knowles, M.A., LL.M., Litt.D., Professor of Economic History in the University of London. London: George Routledge & Sons, Ltd. 10*s*. 6*d*. net.

"To know something about the Overseas Empire at the present day is to get some idea of the whole evolution of civilisation." In this aphorism Mrs. Knowles indicates briefly the nature of the stupendous task which she has undertaken. The British Empire ranges from the Arctic to the Antartic zone; its peoples are in every stage of development; it contains almost every stage of industrial development and almost every agricultural and labour problem. "Every product, every clime, every religion, every stage, every possibility, and consequently every experiment and every problem, are encountered in the study of the economic development of the British Empire."

To attempt to boil down this multifarious and, indeed, infinite subject into a book of any reasonable size might well have appalled the boldest, but the work may be said to be the child of necessity. Mrs. Knowles was appointed to lecture at the London School of Economics on the Economic Development of the British Empire, a compulsory subject for the degree of Bachelor of Commerce, and she found that there were no text-books suitable for her students. In the smallest list that could be produced, there were references to no less than seventy books, reports and articles, and this by no means covered the ground. With a courage for which we cannot express too warmly our admiration, she set to work herself, and has produced this intensely informative and eminently readable volume.

The author found that her chief difficulty lay in the scattered and patchy nature of the material available. As a matter of fact, the economic history of most regions is not yet written. Even if it were, the mind that could grasp it in all its ramifications can hardly be expected to exist. As Mrs. Knowles writes: "In a book which ranges from slavery to Factory Acts, from cold storage to ticks and mosquitoes, from peasant culture to plantation products, from bush paths to railways, there are bound to be many gaps." But it is surprising that the gaps are so few, and that the author has such a firm grasp of so many completely different aspects of her subject.

The present volume is divided into two parts, "The Empire as a Whole," and "The British Tropics"; it will be followed by a second volume, dealing with the economic histories of Canada, Australia, New Zealand, the Union of South Africa, and Rhodesia. When the whole is complete it will provide a most admirable synoptic account of the British Empire.

The London School of Economics has now published seventy-six monographs by writers connected with the School. Many of these are very useful contributions to political science, but none of them can compare for general interest and value with this remarkable work by Mrs. Knowles.

THE ROYAL DOULTON POTTERIES. A brief summary of their rise and expansion during six reigns.

In 1815 the foundation stone was laid of what was to become a great and flourishing firm. Two young men, John Watts and John Doulton, started a small pottery in Vauxhall Walk, Lambeth, a district which has long been known as a centre of this industry. A photograph in the volume under notice shows a collection of clay tobacco pipes of the Stuart period, specimens of which are frequently excavated on the company's property.

Originally the staple output of the firm consisted of "stoneware," but about 1830 some red-glazed ware and garden pots were made, while later on a kiln was erected specially for large terra-cotta work. The entry into the firm of Mr. (afterwards Sir) Henry Doulton marked the beginning of great developments. He was the first to introduce steam for driving the wheels, in this ante-dating by ten years the use of steam for this purpose in any other pottery; and he was also the first to realise the significance to the industry of Mr. Edwin Chadwick's suggestion that glazed pipes should be used for sewers. In 1846 he erected a special factory for the production of pipes and other articles of stoneware for house and town drainage. The superiority of these salt-glazed stoneware pipes over the old and filthy brick drains was speedily recognised, and in addition to the Lambeth works, factories were erected at St. Helens, Rowley and Smethwick.

Another development due to Sir Henry Doulton was the production of what came to be known as "Doulton Ware." Much of this was very beautiful and ranged from the largest *tours de force* in exhibition pieces to the daintiest specimens of fine china. In 1885 the Royal Society of Arts conferred on Sir Henry Doulton their Albert Medal "in recognition of the impulse given by him to the production of artistic pottery in this country."

This book, with its fine photographs and coloured plates, gives an excellent idea of the size and ramifications of the great firm which, founded over a century ago, is to-day running more strongly than ever.

THE ESSENTIALS OF PRINTING. By Frank S. Henry. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd. 6*s*. 6*d*. net.

This is a text-book for beginners, and is a shorter and less elaborate work than the author's "Printing for School and Shop." Written in very simple language, it explains to the novice the operations necessary to the production of a piece of printed matter. The book appears to be admirably adapted to its purpose. Mr. Henry was formerly instructor in printing at Philadelphia Trade School; he, therefore, is familiar with the wants of students of printing, and he has the technical knowledge to supply these wants. A useful feature of the book is that a questionnaire is appended to each chapter. By means of these the reader can test his grasp of what he has read, and by the time he has finished the volume he should have a good understanding of everything connected with printing processes, from the various kinds of type to machines for cutting paper.

COLLECTIVE INDEX OF THE JOURNAL OF THE INSTITUTE OF BREWING, 1911-23. Compiled by W. H. Bird, Secretary of the Institute of Brewing. London: Harrison & Sons, Ltd.

This is an admirable index of the *Journal* of the Institute of Brewing for the years 1911-23. It is divided into four parts: (1) Authors; (ii) Subjects; (iii) General matter; and (iv) Lists of Journals from which communications have been abstracted. The work has been carried out with great care; reference is made as easy as possible; and the index should be indispensable to anyone interested in the brewing industry.

THE BRAZIL-NUT OR CASTANHA INDUSTRY OF BRAZIL.

The castanha, or Brazil-nut, is assuming an important position in the export trade of Brazil. At the present time it stands next to rubber as a source of wealth in the State of Amazonas, where more than one-half the nuts exported are produced. The following particulars regarding the Brazil-nut industry, obtained by a representative of the United States Department of Commerce, who ascended the Amazon River and some of its tributaries in making a study of rubber production, are taken from a special Bulletin published by the U.S. Bureau of Foreign and Domestic Commerce:

The Brazil-nut industry, which was of little importance until a few years ago, has recently developed to such an extent as to eclipse in importance all of the other industries of the Amazon Valley, with the single exception of the rubber industry. During the last few years the latter industry has also felt the inroads being made upon it by the prospering Brazil-nut industry. Especially during the past five years, owing to the unprecedented high prices ruling for castanha (as the Brazil-nut is locally known), the interest in the gathering and marketing of this forest resource of Amazonia has attracted much attention on the part of those ordinarily interested only in rubber.

The rise in importance of the castanha industry may be attributed primarily to the very low price prevailing for rubber, making the production of that product practically unremunerative in Brazil, in combination with the above-mentioned high prices for castanha. Another element, and a most extraordinary one, in the increase in production of castanha is a result of the unusually high rises of the rivers which have occurred during recent years. This great increase in the amount of water in the rivers during the rainy season has made possible canoe navigation for greater distances from the main rivers than was previously the case, thus giving access to larger areas of castanha forest. Aside from natural conditions influencing the yield of the trees, the quantity of castanha produced depends on facilities of transportation, for the greater the distance that the forest can be penetrated the greater will be the number of trees the fruit of which can be marketed.

DESCRIPTION OF THE TREE.

The Brazil-nut tree, commonly so called because it is found almost exclusively in Brazil, where it is indigenous, is known to science as *Bertholletia excelsa*. The name given to it in Brazil, however, is "castanha do Para" (Para chestnut) owing to the fact that all Brazilian Amazon country where

the nut is encountered was known as Para until 1850, when the State of Amazonas, whose castanha production is now slightly in excess of that of Para, came into existence. Similarly, the name "castanha de Maranhao" was applied before the formation of the State of Para, when all this region was included in the State of Maranhao, but this name is now obsolete.

The tree is one of the largest found in the South American jungles, often attaining a height of more than 150 feet and a diameter of 6 feet at the base of the trunk. In the Rio Trombetas, one of the most important castanha regions, a tree was observed which measured 10 feet in diameter. The tree is unique in appearance among the others surrounding it, being distinguishable by its long straight trunk with the branches limited to its upper section. It is by nature a tree of the terra firma, where it is generally encountered in large groves. A few trees are encountered near the streams, but these are always situated on high areas well above flood water. In order to find trees in sufficient numbers to work it is often necessary to penetrate the forests 20 to 30 kilometres from the main streams. The bark of the tree is of a dark colour, and the leaves are large, deeply ribbed, and dark green in colour. The flower or blossom appears as a small white cluster, the period in which the trees flower being October to March, and the time required for the fruit to develop from the blossom stage is about 14 months. Therefore, the fruit of a tree flowering in October will fall in December of the following year.

In the Acre Territory and Rio Negro region there is a slight variation in the flowering time as compared with the other regions, owing to climatic differences, and consequently the gathering time in these two areas does not coincide with that of the other castanha producing regions. The "castanheiras" (castanha trees) of the two areas named flower from one to two months earlier than the trees of the other regions. The tree flowers first when it is in its fifth year, but does not begin to give fruit until the eighth year. At 12 years of age the tree usually begins producing to the full amount of which it is capable.

Castanha is found in greater abundance than any other fruit in Amazonia, and because of this abundance of a natural and fully developed source of wealth the castanha has combined with rubber, cacao, and the other products indigenous to this region to make the Amazon Valley dependent upon them for its economic existence even up to the present. The fruit of the castanha tree is similar in shape and size to the coconut and varies from 3 to 6 inches in diameter. It weighs from 2 to 3 pounds. The cask or outer shell, called "ouriço," is exceedingly hard and about half an inch in thickness. Inside this shell are found from 12 to 22 nuts, depending on the size of the ouriço, all fitted tightly together in juxtaposition. It is these inner nuts, containing the rich oleaginous fruit, with which the consumer outside of Brazil is acquainted. A castanheira is capable of giving from 500 to 1,000 pounds of nuts, not including the weight of the large outer shell.

History of Industry.

The first record of exports of castanha dates from 1836. The trade was of little consequence at that time, as the chief interest was in cacao, rice, cotton, hides, and coffee. It is probable, however, that a small amount of trade in castanha existed long before this, for references are encountered regarding trade between the Dutch and the aborigines of the Amazon country, even before the entrance there of the Portuguese, in various native products, among which are mentioned oil-bearing and edible forest fruits. By 1850 castanha had risen to third place among the exports of Amazonia. During this period rubber had become the most valuable export, being slightly in excess of the value of the cacao exports, while the value of rice, cotton, and coffee had dwindled to very inconsiderable quantities. Hides were fourth in importance at that time. In 1900 rubber exports were many times the value of the exports of cacao. Castanha exports, despite a considerable increase in value, were still third. During the early years of the twentieth century, owing to the greater remuneration offered, the chief interest of the people was in rubber, to the great disadvantage of other industries. Since 1914 castanha has been the second crop of Amazonia, the increase in the price of the nut, together with the fall in the price of rubber, causing a rapid development in the industry, and giving it an especial importance.

Distribution.

The castanha tree is native to the Amazon Valley, and although several attempts have been made to grow the tree in other regions they have been generally unsuccessful. However, experimental plantings of the ouriços in the Far East are said to be giving satisfactory results. The region where the castanha has its home may be roughly sketched to include practically all the lower Amazon Basin, especially north of the main river, and that part of the basin of the upper Amazon (Solimoes) as far as the upper Beni in the Madeira system, at about 13° south latitude, and the eastern section of the Acre Territory. From here the castanha territory extends northward, following the highland of the various tributaries of the Amazon. Castanha abounds in the Rio Negro and its chief tributary, the Rio Branco, and in the region above Manaos on both sides of the Solimoes for about half the distance from Manaos to the Peruvian border. This species of castanha does not occur in Peru, but another species of edible nut, sometimes classified as castanha, is exported in small quantities from Iquitos.

Throughout the wide area where castanha is found several different grades of the nut exist. On the markets of Para and Manaos they are classified according to size and are divided into three grades—large, medium, and small. The largest and most valuable grade comes from (1) the high land on either side of the Solimoes and particularly in the region of Codajaz, where the nut attains such large

proportions that it is considered preferable to the nuts usually classified as "large" and is sold as "grandissima" (extra large); (2) the Rio Negro, and (3) the following areas in the lower Amazon: The high country in the municipality of Obidos, especially in the Rio Trombetas and its affluents and in the lands bordering the Maues and other streams in that section. The grade known as "media" (medium) is encountered in the greatest quantities, being common to the sections where the large grade grows and many other areas where the castanha is all "medium" and "small." Nearly all of the castanha in the lower Amazon, with the exception of that growing in the Trombetas and Maues rivers, mentioned above, is "medium" and "small." The castanha of the Acre Territory and the neighbouring region in Bolivia is also "small" (miuda.) In the upper Amazon the nuts are nearly always of the "large" and "medium" sizes, few "small" being encountered.

In the state of Para about 60 per cent. of the castanha is produced in the three municipal districts of Obidos, Alemquer, and Almeirim—all on the north side of the Amazon. In the State of Amazonas the greater part of the castanha comes from the regions of the Rios Negro, Solimoes, Purus, Medeira and Maues.

During the past two or three years production in the State of Amazonas has increased in such proportions that it is now slightly exceeding that of the State of Para.

EXPORTS OF BRAZIL NUTS FROM THE AMAZON VALLEY.
[Quantities in hectolitres of 112 pounds.]

Year.	From Para	From Manaos	Total	To Europe	To United States
1914......	130,997	198,937	329,934	135,447	194,487
1915......	63,193	79,865	143,058	74,940	68,118
1916......	74,670	124,865	199,535	77,277	122,258
1917......	188,401	148,303	336,704	43,120	293,584
1918......	79,638	64,580	144,218	31,483	89,087
1919......	221,374	335,875	557,249	139,229	418,020
1920......	79,561	109,675	189,236	73,458	115,778
1921......	216,705	297,377	514,082	169,094	344,840
1922......	321,199	361,323	682,522	312,009	369,445

NOTE.—Shipments to southern Brazil were made as follows: 1918, 23,648 hectolitres; 1921, 148 hectolitres and 1922, 1,068 hectolitres.

From the foregoing table the recent rapid increase in production can be seen. The large fluctuation in the yearly production during this period is chiefly due to the labour supply, which in years when rubber paid well neglected the gathering of castanha and *vice versa*. Prices have also increased, and during 1923 the maximum price reached 100 milreis per hectolitre in the early part of the year.

The United States generally takes the greater part of the castanha exported. By far the larger portion of the consignments to Europe is destined for England. France and Germany and to a lesser extent Italy and Belgium are also purchasers of castanha. The market in the south of Brazil is unimportant.

PERIOD OF GATHERING.

The period for gathering the nuts extends generally from November until June, the greater part of the crop falling from January to March. Because of the vast areas to be covered, however, the work is usually carried on through June. In the Acre Territory and the Rio Negro region the nuts begin to fall in November, thus being ready for market over a month in advance of the nuts from the other regions. This is an important advantage for the nuts of these regions, as the Christmas season is the time when they have the greatest sale, and by hastening the gathering here it is possible to secure the advantage of the higher prices which always rule for castanha during the holiday season.

METHOD OF GATHERING.

When the castanha nut reaches maturity, the winds cause the large round hulls to fall to the ground, which they hit with sufficient impact to bury themselves well in the earth when they fall in soft soil. The work of gathering castanha from under the trees is perilous, for it is not an unheard-of occurrence for gatherers to be severely injured, at times fatally, by the heavy nuts falling from the upper part of these high trees. In order to mitigate the dangers connected with the collecting of the nuts, the gatherers set up a shack of thatched palm with a steep slope to the roof in the middle of the forest area which they intend to work. When there is little or no breeze they set out to gather the nuts already fallen. The nuts are thrown out from under the trees as quickly as possible and then gathered in baskets and carried on the backs of the gatherers to their hut. This continues until all the nuts have fallen. The workers utilise the time when the wind is so strong as to make it dangerous to go under the trees in breaking open the outside hulls with machetes and extracting the nuts contained within. These inner nuts are carried to a neighbouring stream, whence they are conveyed by canoes to the nearest shipping point, usually the "barracao" or settlement where the owner of the property resides. The gatherers are bound by the law of the region to sell their castanha only to the owner of the property on which they are found.

Before they are delivered to the proprietor the nuts are washed thoroughly to give them a clean appearance. A slightly better price is realised on washed nuts. The average daily production per man is 1½ "barricas" (1 barrica equals 120 quarts.) The maximum production per man during the entire gathering season never exceeds 70 barricas, and the average production in the castanhaes of all the workers, including the many who are physically unable to work more than a small part of the time, is not more than 20 barricas.

MARKETING.

The marketing of castanha is carried out differently from that of any other product of these regions. The nuts are sent from the barracao to the Manaos or Para markets for sale. A class of merchants known as "aviadores," or commission merchants, handle the nuts from the time they leave the barracao until they are sold to the exporters. A few of these aviadores are exporters, but the majority of them are merely engaged in

buying produce from the proprietors in the interior and marketing it in Manaos or Para, where they all have merchandising establishments. They furnish the proprietors with merchandise to be sold to the gatherers and make balance payments in cash. In Para and Manaos there are brokers who negotiate sales of nuts to the exporters for the aviadores. Those aviadores who do an exporting business do not, of course, need the services of a broker but fill their foreign orders from the nuts which they have procured directly from the proprietors. The profit of the aviador is gained from his commission, generally 10 per cent., which he charges the proprietor for handling the nuts, and the profit realised on the goods he sells to the proprietor. The other expenses, involving freight, insurance, payment of the municipal tax, etc., are all for the account of the proprietor. All expenses arising from wharfage, lighterage, storage, etc., before the sale of the nuts to the exporter must also be borne by the proprietor, who is still the owner of the nuts.

The market price is fixed by auction, the bidding for the nuts being carried out in the Associaçao Comercial (Chamber of Commerce) in Para and Manaos; and the rate at which the nuts are sold, being the highest bid of an exporter, is the official quotation of the day, and the exporters must pay this rate to secure nuts with which to fill their orders from abroad.

By-Products.

The large outer cask of the castanha furnishes a species of oakum used widely for calking ships, while the oil extracted from the nuts serves several purposes. It gives an illuminating oil which until a few years ago was extensively used in the Amazon Valley. The oil also contains certain medicinal properties which make it useful in pharmacy. It is also used in a special form to counteract the rusting of iron. The wood of the tree is used in naval construction, although there is little castanha lumber produced, owing to the fact that the value of the lumber does not justify the destruction of the tree and the consequent loss of its produce.

Plantation Possibilities.

Considering the success which has attended the plantation of rubber trees it would seem that a similar success would reward the planting of castanha, yet little effort has been made to develop plantations of this tree. Up to the present there has always been a ready market for all the castanha shipped from Brazil, and with the constantly increasing imports of these nuts into the United States, England, and to a lesser extent several other European countries, it is evident that Brazil's present production will soon be insufficient to meet the demand from abroad. For this reason it would seem that castanha plantations would be in favour in Brazil, but the great inaccessible castanha areas yet to be exploited have no doubt drawn the attention of the Amazonian proprietors of land away from planting.

A plantation of some 10,000 trees near Obidos was destroyed by fire when the trees were progressing favourably. Another plantation of a few hundred trees was observed at Codajaz, on the Solimoes River above Manaos. These trees ranged in age from one to five years. The youngest were about 6 feet in height and averaged 3 inches in circumference, while those 5 years of age stood 25 feet high and averaged 24 inches in circumference. The oldest trees were in flower at the time the plantation was visited, and should reach the production stage within three or four years. The plantation had been set out on land not entirely free from inundation, although the terrain was elevated and the drainage was good. Inasmuch as the castanheira is essentially a tree of the high land, these trees would probably have progressed more favourably had the site for the plantation been located on true terra firma. Moreover, very little attention had been given to the care of the plantation, and the trees have, therefore, made no more headway than if they had developed naturally in the forest. A well-administered plantation, where proper regard would be had for the distance between the trees in planting, for the eradication of all other growths, etc., would undoubtedly show more promising results than have been obtained here.

"Paradise Nut."

The nut known as "sapucaia" in Brazil (*Lecythis paraensis*) and "paradise nut" in the United States is little known because of the very small quantity that is produced. The sapucaia is similar to the Brazil-nut in that it consists of many small nuts which develop within a large ouriço, just as the Brazil-nut develops. In shape and taste they differ. The sapucaia tree is almost always found on the low level land of the lower Amazon. In this respect it differs from the castanheira, which, as has been noted, is always found on the high land. Small plantations of the sapucaia tree on the alluvial areas of the lower Amazon have developed very favourably. They commence to bear fruit in their fifth or sixth year.

The methods employed in the gathering and marketing of this fruit are the same as for the Brazil-nut. Much better prices are realised on the sapucaia, however, and there is always a ready market for the small amount produced. Owing to the fact that this nut commands a better price and the tree begins to bear at a considerably younger age than the castanheira, it is reasonable to suppose that plantation development would be a more attractive enterprise than the growing of castanha. In addition to its use as a food product, the sapucaia produces a yellow oil, which when fresh is used as olive oil. The principal use of the oil is in making a high-grade white aromatic soap. All the sapucaia exported proceeds from Para, and in 1921 the total amounted to 38 hectolitres, whereas the 1922 exports amounted to 124 hectolitres. The price of sapucaia is generally double that for castanha.

Journal of the Royal Society of Arts.

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FRIDAY, OCTOBER 31, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.2.

NOTICES.

POSTPONEMENT OF OPENING MEETING.

Senatore G. Marconi G.C.V.O., LL.D., D.Sc., (Chairman of the Council), has been unavoidably detained abroad on urgent business and will not be able to return to London by November 5th. The Opening Meeting which was fixed for that date has therefore been postponed. As soon as it is possible to arrange a fresh date, notice will be given in the *Journal.*

The other meetings of the Society will be held in accordance with the announcements printed in the Programme of Sessional Arrangements, copies of which have been posted to all Fellows of the Society.

PETER LE NEVE FOSTER PRIZE.

The late Mr. Reginald Le Neve Foster presented the Society with a donation of £140 for the purpose of founding a Prize in commemoration of his father, Mr. Peter Le Neve Foster, who was Secretary of the Society from 1853 to 1879.

The Council have resolved to offer the Prize of £25 for an essay on "The Effect of Trade Union Regulations on Industrial Output."

Intending competitors must send in their essays not later than March 31st, 1925, to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C.2.

The essays must be typed or clearly written. They may be sent in under the author's name, or under a motto, accompanied by a sealed envelope enclosing the name, as preferred.

The judges will be appointed by the Council.

The Council reserve the right of withholding the Prize or of awarding a smaller Prize or smaller Prizes, if in the opinion of the Judges nothing deserving the full award is submitted.

GEORGE KENNETH MENZIES.
Secretary.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

COLLOID CHEMISTRY.

By ERIC K. RIDEAL, M.B.E., Ph.D., D.Sc., F.I.C.

LECTURE III.—*Delivered February 4th,* 1924

An emulsion consists of a liquid phase dispersed in another liquid phase, *e.g.*, oil dispersed in water. It is evident that we may obtain with the same pair of liquids another emulsion with inverted phases, *e.g.*, water dispersed in oil.

In preparing an emulsion by shaking up two pure immiscible liquids together, we notice that although, under favourable conditions of agitation, the solution may become turbid and an emulsion be formed, yet in a short time the emulsion breaks or separates again into two layers. By dispersing one liquid in another we increase the interfacial surface energy and although, as we saw in our first lecture, the interfacial surface energies of liquids are much smaller than between solids and liquids, yet they are frequently sufficiently great to cause separation of the emulsion unless we introduce some mechanism for the prevention of coalescence caused by the Browman agitation. Emulsions of solid paraffin in heavy oil such as vaseline may be cited as a case of apparent stability due to the slow rate of diffusion. The two general methods of stabilising dispersed solid phases were, as we noted, the introduction of electric charges or the formation of a surface film. In the case of emulsions also these methods may be employed, the lowering of the interfacial surface tension by the addition of a stabilising agent being, however, most general.

For a definite film to be formed at the interface between two liquids the stabilising agent must lower the surface tension of both liquids. We have noted that in the case of

the fatty acids floating upon water the molecules in the film are orientated; thus we should expect to find that the layer of molecules of the stabilising agent, causing the film at the surface between two liquids, is likewise orientated. This conception throws a great deal of light on the conditions under which a particular liquid will become the disperse phase on emulsification.

If we consider a perfectly plane sheet of interface

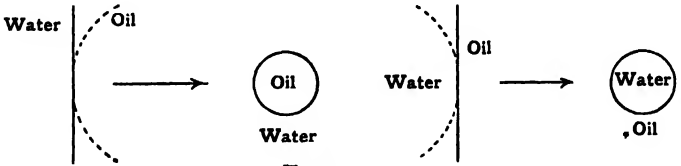

FIG. 3.

Metal Soap	Stability	Atomic Volume
Cs	8 weeks	70·6
K	8 weeks	45·3
Na	6 weeks	22·9

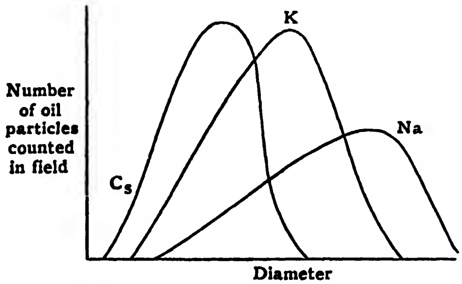

FIG. 4.

it is evident that if the sheet bends towards the oil layer the oil will become the internal phase. On the addition of a soap such as sodium oleate to the mixture of the two liquids, the soap goes to the interface and in accordance with our hypothesis becomes orientated there

Water.	Oil.
NaOOC	R
NaOOC	R
NaOOC	R

We found that the cross sectional area of the hydrocarbon chain was *ca* 21 A°; thus if the cross sectional area of the hydrated —COONa head is greater than 21 A° the molecules of the film will be more closely crowded on the water than on the oil side; thus the action of the film will be to increase the available area on the water side at the expense of a crowding in of the tails and we shall obtain an oil in water emulsion.

Although the degree of hydration, and thus the effective area of the heads constituting the metallic salts of the fatty acids, are unknown some conception of their minimum value may be obtained from a knowledge of the specific volume of the metal forming the soap. The following data of Hildebrand indicate the correlation between the stability and size of the oil in water emulsion with the atomic value of metal:

Metal Soap.	Stability.	Atomic volume.
Cs	8 weeks	70.6
K	8 weeks	45.3
Na	6 weeks	22.9

It will be noted how the curvature and the stability of the oil particles increase with increasing size of the head of the stabilising molecule.

In the case of silver oleate $VAg = 10.3$ the head is now so small that it can apparently be more easily compressed than the tail to a smaller area, and thus we obtain a very unstable (one day) water in oil emulsion.

In the case of groups of the divalent elements *Ca*, *Mg*, *Zn*, and of the trivalent ions, aluminium and iron, the cross sectional area of two and three hydrocarbon chains respectively is greater than one head, and we thus always obtain water in oil emulsions.

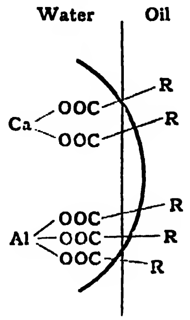

FIG. 5.

But here again the close correspondence between stability and head size as computed by means of the atomic volumes is evident.

Soap.	Stability.	Atomic value.
Ca″	1 hour	12.6
Mg″	2 days	7.0
Zn″	24 days	4.6
Al‴	7 days	3.4
Fe‴	10 days	2.3

This property of inversion of the more usual oil in water emulsions to a water in oil emulsion by the change in the stabilising agent from, say, a sodium oleate to a calcium oleate, has been made use of in a number of industrial operations, and appears to be of fundamental importance to the biologist. Lubricating oils which, as we have seen, contain small quantities of fatty acids or alkali metal soaps on admixture and dispersion with water will naturally form an oil in water emulsion, but on the addition of a trace of lime the phases will invert and we obtain a grease with oil as the continuous phase. The hard waters exert a similar action on soaps employed for washing materials containing oils, the continuous oil phase being extremely difficult to remove. Again the fact that water may be made the disperse phase and in consequence produce but little change in the appearance of the material gives us a convenient and easy method of adulteration in such substances as varied as white-lead, leather dubbing and butter.

Clowes has shown that by a suitable admixture of calcium and sodium soaps it is possible to prepare an emulsion which is practically balanced; the slightest addition of sodium soap will throw it over to the oil in water type; whilst the calcium will effect the contrary action. The balanced oil emulsion is seen from the work of Loeb and Osterhout to be of biological importance since marine organisms will apparently only flourish in solutions in which the liquids of the protoplasm are in this unstable state as regards phase inversion. It is of interest to note that the calcium sodium ion ratio in sea-water is practically identical with the ratio, formed by Clowes, necessary to prepare a balanced emulsion.

The emulsions thus require stabilising agents which naturally vary with the type of emulsion. In milk, the milk fat is emulsified in water, being stabilised by the naturally occurring albuminous substance casein, which in turn is protected by the lact-albumen. In rubber latex the hydrocarbon complex of isoprene and its homologues are stabilised by a naturally occurring protein which is apparently not without effect on the rate of vulcanisation.

In the preparation of the emulsified coal tar disinfectants the fineness of the dispersion of the high boiling point of tar acids in water, as well as their subsequent stability, depends in great measure on the nature of the stabilising agents employed, both soaps and other stabilising agents such as gelatine being employed.

Artificial milks may readily be prepared by the emulsification of 3% of oil with a stabilising agent such as the protein matter of the soya bean or the casein from skim milk, small quantities of lactose or other sugars being added to imitate natural milk.

Since the emulsoids possess a lower interfacial surface tension than the suspensoids they do not absorb ions from solution as readily as the colloidal metals, and are thus not so sensitive to precipitation. We have already noted how, by the protection of a suspension such as gold with an emulsion such as gelatine, a great enhancement in stability may be obtained.

The emulsoids are, however, by no means insensitive to electrolytes, and an emulsion will "break" and separate into its phases when the electrokinetic potential has dropped to below the critical value of $\pm$ 30 millevolts. The breaking of such emulsions is an important problem to be considered in the refining of vegetable and some mineral oils in the cream and butter industries, and in the preparation of rubber from latex, whilst the need for some test on the protection against breaking for disinfectants employed in the presence of salts is very evident.

Coalescence of the emulsoid particles may also be prevented by the addition of solids which are more easily wetted by one liquid than by the other. Thus Pickering has obtained emulsions of oil in water with basic iron copper and metal salts and more with the aid of carbon. A study of the composite nature of the mechanical skin indicates clearly that the external phase must be the one which displaces the other from the particle surface, exerting a wedge pressure similar to that exerted by the molecules of the soaps.

If we imagine the disperse phase to grow in a point will come when the spheres of the phase just touch one another. This occurs when the free space

left is some $\frac{1}{3}\frac{2}{7}$ of the total volume. If the spheres were undeformable this would be the upper limit of the emulsion, but spheres consisting of a liquid can be deformed, and in fact Pickering has been able to obtain as high as 99% of disperse phase. The emulsoid thus acquires a polyhedral structure and in appearance is like a blancmange or jelly. For such emulsions in which the continuous phase is practically confined to the surface layer it is evident that the protective film must be exceedingly strong.

Before leaving the subject of the emulsoids I should like to refer to an important test which is apparently a purely colloidal reaction. I refer to the precipitation tests employed in the diagnosis of syphilis. The general method of testing for luetic serum is to compare the precipitating power of normal and luetic serum or cerebro-spinal fluid on an emulsoid termed an antigen. From a consideration of the vast number of modifications of antigens which can be employed it would appear that the precipitating reaction is in reality the result of the mutual action of an electronegative colloidal suspension with an electropositive material present in luetic serum and cerebrospinal fluid, but present in much smaller quantites in normal sera. The electro-negative antigen must be brought to the requisite degree of sensitiveness for it to come within the precipitating region of 30 millevolts on the addition of small quantities of serum. It would appear probable that as our knowledge of colloidal protection increases we should be able to prepare colloidal emulsions of the required sensitiveness without having recourse to the various complex heart extracts embodied in many of the preparations.

The jellies or greases prepared in the manner described are, however, entirely different in structure from the adsorbing jels, such as silica, alumina or ferric oxide. We have already noted that we can precipitate a substance like barium sulphate in a form which is not macrocrystalline or granular, but as a jelly containing appreciable quantities of solvent. The hydrated oxides of iron and copper can be precipitated in a flocculent form at low, and a granular form at high temperatures, even more gelatinous are the precipitates of alumina, silica and gelatine. Flocculent precipitates evidently represent a transitional stage between granular precipitates and gels, which are always prepared by methods of condensation either as the result of interaction of two reagents, or by cooling a solution containing a gel forming material of a high solubility temperature coefficient.

The gels evidently consist of two phases, one a solid and the other a liquid, and the question arises as to the structure of the solid phase. We have already noted that emulsions may be prepared in a rigid form and that these possess a honey-comb or polyhedral structure, and for a long time it was considered that such a structure must be attributed to the true gels. The gels are exceedingly elastic, a point somewhat difficult to explain if they consist of isolated spherical particles embedded in a relatively non-elastic medium; further they are relatively extremely rigid, and these and many other properties are best interpreted on the assumption that the solid phase of the gels consists of a number of particles joined together to form relatively short fibrils or threads which intersect one another in all possible directions to form a gel in the irregular meshes of which the mobile liquid phase penetrates. Under high magnification in coarse gels such as dibenzoyl cystine and some soaps the fibrillar structure can be readily observed. The X-ray examination of a number of gels including silica, stannic oxide and vegetable fibres such as cellulose and ramie fibre, has confirmed the presence of a crystalline structure in these gels.

The fibrillar structure is likewise supported by examination of the crystals of gel forming substances; they are almost invariably long and needle shaped such as benzophenone and dibenzoyl cystine molecules and can apparently hang on to one another in a series of chains; thus we can imagine a chain formation in a soap to take place by the following:

$$\begin{array}{l} CH_3CH_2\ Na \\ \qquad NaOOC{-}CH_2CH_2{-}CH_3 \\ \qquad\qquad\qquad NaOOC{-}CH_2CH_2CH_3 \\ \qquad CH_3CH_2{-}COONa \qquad CH_3CH_2{-} \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad COONa \end{array}$$

the mutual adhesion between the non-polar and the polar ends prolonging the molecular structure.

Similarly, we may readily imagine a chain formation in the gelatinous hydroxides; thus Pauli has brought forward evidence for the existence of salts of the type

$$[Zn\,(OH)_4\ Zn\,(OH)_4\ Zn\ O\ Cl_2\ Zn\ \overset{++}{O}]\ Cl_2''$$

$$[Zn(OH)_4\ Zn\ O\ Cl_2\ Zn\ \overset{++}{O}]\ Cl_2''$$

$$[Zn(OH)_4\ Zn\ \overset{++}{O}]\ Cl_2''$$

Gels consisting of fine fibrils are usually dry and rigid, whilst the coarser the fibril the more moist and elastic do they become. Silica and gelatine may be cited as examples of each case. The rigid gels may be dried and the interfibrillar liquid removed without collapse, and indeed it has been found possible to replace the water in a silica gel by other liquids, such as alcohol or benzene. The interfibrillar volume and average diameter of the interfibrillar capillaries per gm. of a silica gel have been measured with the following results:

Liquid.	*In c.c. per. gm. of gel.*	*δ of capillaries. Largest*	*Smallest.*
Water	0,6210	54·9 A	27·5 A
Benzene	0,6270	59·8 A	27·0 A
Acetylene tetrabromide	0,6160		

The gels possess many interesting electrical properties which are of great importance in the practice of dyeing the crystalline gels, such as cotton, silk fibre and wool, and in the process of tanning.

The gel fibres are generally charged, those of wool, silk and cotton acquiring a negative charge in water; positively charged dyes of the methylene blue type will readily be adsorbed and thus effect dyeing of the fibre. In the same way many positively charged sols of the metallic hydroxides, such as aluminium, iron chromium and tin, are adsorbed and act as mordants. The fibres of silk and wool, however, appear to behave in some respects like gelatine, which we noted when discussing protection could acquire either a positive charge in acid solution or a negative charge in alkaline solutions. The most plausible assumption to explain this phenomenon is to assume that these fibres, like gelatine, contain both acid and basic groups, and are in fact amphoteric electrolytes. It is thus clear that acid as well as basic dyes can be caused to adhere to silk and wool fibres by attachment to the basic groupings which confer on the colloid its positive charge on combination with hydrogen ions. The fact that the gel fibres are charged and are in all probability highly solvated likewise gives a ready interpretation of the fact that most gels will swell when immersed in dilute acids or alkalies, but the water content is at a minimum at the isoelectric point. This has been elucidated by the work of Professor Donnan at University College on membrane equilibria. We may take as a typical instance the case of gelatine in a dilute and hydrochloric solution. Part of the gelatine G is converted into gelatine hydrochloric GH Cl, which ionises into its ions $\overset{+}{\mathrm{GH}}$ $\dot{\mathrm{Cl}}$. The $\overset{+}{\mathrm{GH}}$ ion, however, differs from the others in that it is immobilised, being in fact part of the gelatine fibril. We can thus represent the concentrations outside and inside the gelatine fibril diagrammatically as follows:

Inside.	*Outside.*
G	
	$x\ \overset{+}{\mathrm{H}}$
$c\ \overset{+}{\mathrm{GH}}$	
$a\ \overset{+}{\mathrm{H}}$	$x\ \acute{\mathrm{C}}\mathrm{l}$
$b\ \acute{\mathrm{C}}\mathrm{l}$	

Under conditions of equilibrium by the law of mass action we obtain the following relationship:

$$x^2 = ab$$

Hence since $a + b$ must always exceed $2x$ except when $a = b$, the number of diffusible ions inside the solvated gel must exceed those outside. Since the osmotic pressure is due to the diffusible ions this will be greater inside than out, causing the gel to swell until the cohesive elastic force of the fibrils just balances the difference in osmotic pressure. It is evident also that the ionic concentrations on each side of the membrane will be unequal and will give rise to differences of potential; these have been investigated by Donnan and his co-workers and the experimentally determined values agree remarkably closely with the theoretical values expected.

In addition to colloidal systems which I have alluded to during this course of lectures there is one other important class about which I should like to say a few words. I refer to the soaps, many mysteries of which have been revealed by the researches of Professor McBain at Bristol.

The soaps dissolve in alcohol to form simple solutions; in water to form colloidal solutions. The critical examination of physico-chemical properties of aqueous solutions of soap have indicated that the colloidal particles consist of an agglomeration of soap molecules containing water of solvation. These colloidal aggregates are also charged, as shown by experimental work on electric cataphoresis, but they differ from the colloidal aggregates which we have examined in the case of the more usual sols

and emulsoids in that the electric mobility of the charged particles appears to be comparable to that of an ion; and in addition the equivalent conductivity is comparable to that of an ion. This can only be accounted for on the hypothesis that the colloidal particle has undergone extensive surface ionisation; to such particles McBain has given the very fortunate name of ionic micelle and its general chemical formula can be denoted by $(Na\ P)x\ (P')y\ (H_2O)z$.

The saponaceous character of soaps can be imparted to hydro-carbon chains by the insertion of groups such as — COO Na — SO_3 Na — $N(H_3)$ I and other similar polar assemblages and it would appear that the micellar structure and the detergent action of such substances may be attributed to the same cause, *i.e.*, the property of the non-polar hydrocarbon chains adhering to one another or to a hydrocarbon, an adherence which we can represent diagrammatically as follows:

$$\begin{array}{c} COONa \\ (CH_2)_n \\ CH_3 \\ NaOOC\,(CH_2)_n\,CH_3 \quad CH_3\,(CH_2)_n\text{—}COONa \\ CH_3 \\ (CH_2)_n\ COONa \end{array}$$

We have noted in our survey of the properties of colloids that the operation of forces at interfaces may produce unexpected mechanical, chemical and electrical effects, which, however, on ultimate analysis lend themselves to theoretical treatment and experimental verification. In addition we have had occasion to mention a great number of technical and industrial operations in which a proper understanding of surface phenomena is necessary before we may legitimately expect an improvement on the somewhat haphazard and rule of thumb methods frequently employed. There is, however, little doubt that the progress of industrial chemistry will in future be ever increasingly regulated by the tempo of research prosecuted in this important field of physico-chemical investigation.

NOTES ON BOOKS.

REINFORCED CONCRETE DESIGN. By G. P. Manning. London: Longmans, Green and Co. 21s. net.

Mr. Manning presents us with a treatise well suited for the thorough, but active and driving aspects of the present age, and in his total of 484 + XVI pages, with numerous diagrams, graphs, folders, formulæ, and labour-saving tables, our author gives us a full and concisely worded guide to the practice of the time.

A very complete mathematical study of strains, stresses, and the like is embodied in Mr. Manning's volume: and, indeed it may be considered that such study forms the ground-work of the volume, but nevertheless the student is reminded in the preface (p. V) that "long and laborious mathematical processes increase office costs, give greater opportunities for error, and discourage and fatigue the designer."

When one looks more and more closely into the details of Mr. Manning's book, its wholly and unmixedly practical character becomes increasingly manifest. We have no discursive plunges into the history of by-gone times, but we have frequent aphoristic and anecdotal cautions as to dangers and risks which beset the designer who relies too much on theory or on theory alone. This view in no way weakens our author in his thorough mathematical development of the subject even to the smallest details. On p. 468 he tells a story of six persons—he was one of them—who in a preliminary sense passed a design which lacked an essential member, and he points out how comparable blunders are to be avoided; as by frequently pausing in detail work to take general views, and also by a final broad study in which "the designer's common sense will tell him if his sizes are far wrong." As an example of our author's numerous aphorisms, we may quote from p. 402: "Drawings and calculations should be checked over by some person who has taken no part in the preliminary designs."

Domes are dealt with at considerable length in chapter XXIV, and we learn that they have been made with a thickness as low as three inches for a dome of 50 feet in diameter. Among other subjects treated of in separate chapters are chimneys, staircases, flat-slab floors, hollow-tile floors, circular tanks, and bridges.

From the above it will be realised that Mr. Manning's thorough and comprehensive (and we may say admirable) volume is a text-book for the present generation, and in reference to our time condition of somewhat rigid standardisation as regards the cements as sold; also as to the general aspects of reinforced concrete construction. How thoroughly our author realises the present position is shown by the following on p. 468: "Above all things the beginner must pin his faith to standard practice and to actual structures. All theories and text-books should be examined with the utmost scepticism."

It was the illustrious Smeaton and his associate Cookworthy (about 1756) who took the first notable step towards certainty as regards the composition and condition of water resisting calcareous cements; such cements having been in use, on an uncertain basis, for about two thousand years.

Early in the 19th century M. Vicat followed in the path indicated by Cookworthy and made analyses of such limestones found in France a.

were known to yield hydraulic lime. Vicat having thus noted the variable proportions of silica and alumina in the natural hydraulic limestones, he endeavoured to realise the best conditions (or constant or standard conditions) by making the required additions to fat lime, working with water into a paste, and calcining balls made of the paste. The results were so satisfactory that Vicat's cement was used on a large scale at Toulon for public works in 1819 and 1820.

Vicat, in the production of cements which were produced and used on a large scale during those years, employed all the essential features which characterise the present-time manufacture of "Portland Cement" (a term which we think is due to Aspdin), together with the very vital feature of a chemically adjusted or controlled single preparation or frit, independent of such uncertain additions as pozzolana, trass, or an artificial substitute.

The researches of Smeaton and Cookworthy are described in detail on pages 11 to 16 of the printed text of Bertram Blount's "Lectures on Cement," published in 1912 by the Institute of Chemistry, while Vicat's long period of varied labour in relation to cement is detailed in the 1881 edition of the Roret (Paris), "Manuel Complet du Chaufournier."

An Introduction to the Strowger System of Automatic Telephony. By H. H. Harrison. London: Longmans, Green and Co. 7*s.* 6*d.* net.

In his preface Mr. Harrison explains that all the systems but one are similar, so for detailed study he takes the Strowger system, this having been chosen for installation in London. Page 1 of the text embodies a mild protest against the application of the term "automatic" telephony to "an elaborate system of remotely controlled switch-gear in which the calling subscriber exercises a controlling function over centrally located switches." He also (pp. 1 and 2) favours the term "machine-switching," which has been introduced by the American communication engineers, as "more logical"; further, it "accurately defines the functions of the apparatus."

In the case of the Strowger system, which we may expect in London shortly, the removal of the telephone from its switch-hook by the calling subscriber, instead of lighting a lamp at the exchange, sets a highly complex device in motion called a pre-selector, the function of this device (p. 41, Fig. 28) being to take the first mechanical steps towards finding a clear route or path for the new call.

When the pre-selector at the Exchange has functioned and put all in readiness, the calling subscriber has discriminative or indicating work to do, the complexity and difficulty of which must vary much according to the details and magnitude of the system, and for an example of high complexity and difficulty which may arise on the London system, we may refer the reader to pp. 139-140. We fail, however, to gather from Mr. Harrison's book how the calling subscriber is made aware that the pre-selecting machinery has functioned and is ready for him, or of the probable average time required. The main duty of the calling-subscriber is to send impulses of from 1 to 10 in series, at the right time on stages by a calling-dial machine (p. 8, Fig. 8; p. 4, Fig. 32; as to lettering for routes or exchanges p. 139 and p. 141, Fig. 86. There are mechanical features of the Strowger digiting switch or calling-dial, which are worthy of mention, namely, the device for governing or slowing-down speed in passing-on impulses so that they may not be blurred into each other; also the pull round of the disc by the tip of the finger; but as regards the actual working, the instructions will probably vary according to special or local conditions, and our author's final remark on p. 1 suggests that he is by no means sure of a working altogether on the machine basis or without supervisory help, a view much emphasised by his pages (104-110) on supervisory arrangements, mainly in relation to trunk calls.

We think the position may be summarised by postulating that in a small unit, as for inter-communication in a business-house, there is notable economy and convenience in the machine-switching system (or "automatic" system); also for a village or small town, with about 500 instruments, the advantages are real, or about balanced against the disadvantages, but as the scope of the system becomes larger, the disadvantages of machine-switching may tend to increase rapidly owing to the heavy and complex duties imposed on the calling subscriber, and the increased complication of the machinery. The pending experiment in London, the most complex and difficult unit in the world, should be watched with the greatest interest, and there appears to be a general impression that the *crux* of the experiment will centre largely on the question of machine-switching as applied to metering the charges for message rates with zone variations. In America the rule appears to be the non-registration of calls on machine-switching systems, as saving time in the passing of calls. It is suggested in *Nature* (October 11th, 1924, p. 533), that a new tariff system will be proposed (indeed this seems inevitable if the subscriber has to do work hitherto done by the Exchange), but the difficulty of convincing users as to the fairness of proposals is hinted at. The wage value of a telephone operator is approximately a constant, but the wage value of subscribers' time must vary enormously, this perhaps being the economic fact that will bear on the most real difficulties in the London experiment.

We find no particulars as to the minimum possible times for passing calls under specified conditions, nor are we told by Mr. Harrison how ordinary untrained people will pass emergency calls, as police, fire or ambulance, especially in dim light.

This we may say emphatically: Every Londoner should be deeply interested in London's great

experiment on mechanical telephony, and should carefully study Mr. Harrison's lucidly written and well illustrated book.

Dock Labour and Decasualisation. By E. C. P. Lascelles and S. S. Bullock. London: P. S. King and Son, Ltd. 10s. *net*.

Casual service, as distinguished from regular salaried (or wage) service is, in a certain sense, the subject-matter of the work before us, but the scope is pronouncedly narrow; the limitation indicated by the title being so rigidly adhered to as to make the book a study of an exception, or special instance in our social organisation, rather than a study of representative cases calculated to cast light on the general question as to the greater or less desirability of casual work as compared with regular salaried employment.

Many persons, possibly a majority, have a bias towards a kind of social stability which they expect to realise by regular wage service as against casual engagements, and by Mr. Lloyd Jones's 50 year-old principle of a minimum wage for all (*The Beehive*, July, 1874). Other workers, thinkers and economists reject the notion of social stability by the somnolent influence of fixed easy and uncompetitive conditions, and plead for wages in ratio to effort or success; as stimulating true progress and independent character, or mental freedom.

We may, however, bear in mind that very much of our national or staple work, farming for instance, is so fundamentally casual in its nature that occasions arise (haymaking for example) when every available person, whether on the establishment or not, is ordinarily pressed into service. Moreover, a large proportion of the professional work of the nation is so inherently casual in its nature, that to convert it into salaried service seems difficult or impracticable. The medical insurance scheme may be regarded as an effort in this direction.

Our authors, as far as we can gather, do not put forward any definite plea or argument against casual work in general, as contrasted with work at a fixed salary, but they aim at promoting social or syndical, or legislative action to end the stressful and wasteful competition which for seventy years or more has been a feature of the engagement of labour at the dock gates (pp. 1 and 2).

Those who compete for casual work at the docks are, speaking generally, neither those who prefer casual work as such nor standard or normal workmen, but cast-offs from various walks in life of a kind generally to be found in the more densely populated districts of our great cities, and many being within walking distance of the docks, these naturally gather together at the time when work may be expected.

The crowd, we are told (pp. 28-29), includes learned scholars, members of the landed aristocracy, discharged lawyers' clerks and wastrels from some 50 or 60 occupations, but our authors remark that very few men drift from agriculture to the docks; also that "aliens and Jews are now almost unknown in the docks" (p. 30).

We find mention of a better type in p. 47; a glass bottle maker who, as occasion offered, was in the habit of engaging himself as dock labourer, ship repairer, or canvasser. This case seems suggestive. A labour exchange room or shelter near each engaging place might allow the display of notices from employers in the neighbourhood requiring help.

The volume before us is the 74th in the series of monographs by writers connected with the London School of Economics and Political Science; Ratan Tata Foundation. Absence of illustrative historical study in reference to fundamental principles, and the remarkable views as to remedy, views which scarcely go beyond prohibition and the application of interference by irresponsible syndicalism, do not justify us in according to the present volume, the highest position in the above mentioned useful series.

As a remedy we find registration frequently referred to, and from the formal chapter on the subject, pp. 125-132, we learn that "registration" is not to be a mere listing of the names and lodgings of the poor outcasts so as to save them from needless effort and waiting, but an elaborate system, first for selection by "a joint Committee filled with a laudable zeal for decasualisation" (p. 124), and afterwards for exclusion or warning off as the Committee may decide; the first half of page 129 is worth careful study by students of economics as bearing on the suggested powers and action. On p. 98 we read about "officials of the Union, whose business it is to watch the 'calling-on' and prevent the engagement of non-Union interlopers."

Survey of Work of the Granja Modelo en Puno. By Colonel R. J. Stordy, C.B.E., D.S.O.

In 1920 Colonel Robert J. Stordy read a paper before the Society on "The Breeding of Sheep, Llama and Alpaca in Peru," in which he described an experiment about to be made on a wide scale by the Peruvian Government, with a view to supplying finer raw material for the textile trades. At that time the science of breeding was quite unknown in Peru; the sheep were small and degenerate from close in-breeding, and the primitive methods of the natives, who sheared with a knife or a piece of glass, did not tend to improve the quality or increase the quantity of the wool.

The pamphlet under notice gives an account of the progress that has been made during the period May, 1921—July, 1923. A consignment of livestock, including 130 pure-bred rams, 20 pure-bred Suffolk ewes, mares, shorthorn bulls etc., was exported from England in February, 1921. As their ultimate destination at Chuquibambila, is situated in the Sierra at an altitude of 12,000 feet above sea-level, it was necessary to give them a period of acclimatisation on the way. Naturally some casualties occurred both at sea

and on the final stages of their journey, but thanks to the extraordinary skill and care with which they were attended, a very large percentage of the stock reached their destination in good condition.

In a great breeding experiment the period which has so far elapsed is too short to enable the results to be finally judged, but it is satisfactory to learn that the cross-bred lambs which have been already obtained show a marked improvement on the native animal, and the influence of the imported sires is much in evidence. At ages of four to six months the lambs easily outweigh their mothers, and they stand the climatic conditions quite as well as the indigenous stock. The merino cross-breds have been particularly satisfactory and have yielded some beautiful wools, which have been very favourably reported on by Professor Aldred Barker, of the Textile Department of the University of Leeds.

Not only have the sheep themselves been improved by the experiment; the native farmers and shepherds also have learned a great deal about breeding, shearing and the scientific management of stock, and there is every reason to hope that the information freely disseminated from the "Granja Modelo" will exercise a healthy influence over the whole pastoral industry of Peru. Colonel Stordy and his staff are continually experimenting with new types of fodder that can be grown in the Sierra, and some of this work seems likely to prove extraordinarily successful.

The Scottish sheep dogs which accompanied their masters to Peru have done splendidly, and, writes Colonel Stordy, "are the wonder and envy of every Peruvian farmer. All who have witnessed the dogs' intelligent working of sheep have been most anxious to become the proud possessor of one; yet when they hear terms of endearment addressed to them in the broadest Doric, such as 'Creep doun, ye fool,' 'Gie awa' oot, mon,' or 'Ca' 'way to heel, ye muckle gommerle,' the Peruvian farmer thoroughly appreciates that to own and work a dog of Scottish descent is not without its difficulties."

Some Studies in Bio-Chemistry. By Students of Dr. Gilbert J. Fowler, of the Indian Institute of Science. Bangalore: The Phœnix Printing House.

This is a delightful book in all its aspects. It reflects the cordial relations between an eminent teacher and his pupils, and it gives to the world twenty-six essays for the most part on matters of fundamental importance.

Detailed or systematic research on plant physiology and kindred subjects is a leading feature of the present day in public institutions and the present volume illustrates what is being done in India.

Considering the growing importance of the lac industry it is not surprising to find that six out of the twenty-six essays bear on this subject.

On pp. 60 and 61, Mr. Sreenivasaya studies the lac insect as a capillary phenomenon, but this interesting note includes the vegetable host as a part of the dynamic system. Whether to regard lac as a by-product, waste product, or excrementary outcast of the insect, as against the view that lac is the result of normal metabolism, is the problem which Mr. C. Rama Somayajulu has set himself to solve, the practical aim being to control the quality of the product as far as may be possible (pp. 67-70). The study of Mr. Gupta on natural resins and lacs (pp. 71-77) is, like the previously mentioned contribution, largely analytical. Utilisation of secondary products, including lac-dye, is studied by Mr. Venugopalan (pp. 78-83), and although this investigator sees no hope of the historic colouring matter being again used as a staple dyeing material, he thinks that lac-dye lakes (alumina, tin) may have a future as brilliant red pigments.

Adulteration of shellac appears to be a serious matter at the present time if we may judge from Mr. Rangaswami's paper (pp. 84-90), especially the fusion of shellac with orpiment, such arsenical shellac being, it is suggested, used by confectioners in glazing their goods and in brewing establishments for lining the fermentation tanks.

The secretion of the lac insect in relation to symbiotic fungi is studied by Mr. S. Mahdihassan (pp. 187-190). He mentions two insects found in Mysore, whose secretion does not melt like ordinary shellac, and he includes these in his study. We gather that he believes the secretion products of lac insects generally bear a direct relationship to their symbiotic fungi, but the further elaboration of these studies requires a rather thorough correlation of data collected by the chemist, the entomologist, and the botanist.

Vinegar, leather, cotton, fermentation-acetone, alcoholic-fuel, and other subjects come under consideration in the volume before us, but we have selected the work on shellac in our endeavour to give some faint notion of the class of research now in progress at the great Indian station.

MERCANTILE MARINE CONSTRUCTION.

MOTOR VESSELS.

In the last annual report of the Chamber of Shipping of the United Kingdom, it is pointed out that from the technical point of view, the most notable development has been the accelerated construction of motor ships. Of the motor ships afloat when the report was written, aggregating 1,321,131 tons, 374,873 tons were recorded in June, 1923, as being under the British flag; while at the end of the year 55 vessels of 323,641 tonnage which awaited internal combustion engines were under construction in the shipbuilding yards of this country. "That," say the Council, "is a larger amount of shipping of this type than is being built in all the other shipyards of the world." Returns for the last quarter show that at present there are 43 oil tankers being built here and abroad. Of these, 32 of 133,820 tons are under construction

in Great Britain and Ireland, and 11 of 95,500 tons in Germany. The total tonnage of the motor ships under construction at the end of September, 1924, in Great Britain and Ireland was 387,670 tons, representing nearly 36 per cent. of the steam tonnage being built. For all the world the percentage was nearly 58. Taking Germany, Denmark and Sweden together the proportion was nearly 78 per cent.

British shipping, it is stated in the Chamber of Shipping report referred to, is still the most efficient instrument of transport, whether judged by the volume or quality of its tonnage. In June, 1914, 18,877,000 tons (gross register) of shipping were under the British flag, and, in spite of the heavy losses sustained during the war, the amount of shipping at the end of 1923 was larger than it was in 1914 by 200,000 tons, while in the British Dominions the increase had been as much as 812,000 tons. Of the expansion of merchant shipping of all nations which has occurred since the early summer of 1914, amounting in the aggregate to nearly 15,500,000 tons, shipowners in the British Empire were responsible for only just over 1,000,000 tons; the principal contribution to the existing surplus was made by the United States with 10,500,000 tons, while Japan added 1,760,000 tons to her fleet, Italy 1,360,000 tons, France 1,347,000 tons, Holland 1,135,000 tons, and the Scandinavian countries—Norway, Sweden and Denmark—628,000 tons.

In these circumstances the percentage of sea-going shipping of the world owned in the United Kingdom had decreased from just under 44½ per cent. to just under 33 per cent. But these figures, it is explained, cannot be accepted without qualification as indicative of the position of British shipping. Probably half of the 15,500,000 tons might be regarded as obsolete or otherwise uneconomical. The tonnage idle was more than at any pre-war period. At least 6,000,000 tons of shipping under foreign flags was estimated to be unemployed when the report under notice was prepared. Of this huge total two-thirds or more was American, whereas only 750,000 tons was British, "notwithstanding that British shipping is not artificially assisted by subsidies or sheltered by flag discrimination from unrestricted world competition."

The following table shows the tonnage of merchant vessels of 100 tons gross and upwards launched in Great Britain and Ireland, the United States (Coast), Japan and the rest of the world from 1913 to 1923:—

YEAR	GREAT BRITAIN & IRELAND.	U.S.A. (COAST.)	JAPAN.	REST OF THE WORLD
1913	1,932,153	228,232	64,664	1,107,883
1914	1,683,553	162,937	85,861	920,402
1915	650,919	157,167	49,408	344,144
1916	608,235	384,899	145,624	549,322
1917	1,162,896	821,115	350,141	603,634
1918	1,348,120	2,602,153	489,924	1,007,247
1919	1,620,442	3,579,826	611,883	1,332,398
1920	2,055,624	2,348,725	456,642	1,000,675
1921	1,538,052	995,129	227,425	1,581,073
1922	1,031,081	97,161	83,419	1,255,423
1923	645,651	96,491	72,475	828,564

THE CO-OPERATIVE MOVEMENT IN DANISH AGRICULTURE.

In view of the interest recently manifested in Danish Agriculture, the following notes on the co-operative movement in Denmark, taken from the annual Report by the Commercial Secretary at the British Legation, Copenhagen, may be found of interest:

The first supply association was founded in a Danish town in 1866, and was based on the supply of goods to the working population at market prices, and the distribution of profits in proportion to the value of the goods purchased. In the course of time the movement spread and there are now some 2,000 supply associations throughout the country, both in the towns and in the rural districts, with a membership of about 350,000.

In connexion with these supply associations, a "Joint Association of Denmark's Supply Associations" was founded in 1896, for the purpose of making the wholesale purchases for the various supply associations. In the course of time this central association founded a number of industrial undertakings (tobacco, chocolate, soap, margarine, bicycles, rope, knitted goods, leather and footwear, certain kinds of iron goods, and chemical technical articles) for the supply of the goods required, the turnover of these factories amounting in 1921 to Kr. 35,000,000, while in the same year the turnover of the joint association totalled some 175,000,000 kroners.

In 1898 was founded a Co-operative Fodderstuff Purchasing Association, and now between 35 and 40 per cent. of the country's imports of fodder stuffs (oilcake, maize and particularly in 1923, barley) are handled by such associations. Similarly, the Danish Co-operative Fertiliser Association (founded in 1901), supplies fertilisers to some 1,600 local societies throughout the country, with a membership of about 80,000 farmers. The central institution purchases and distributes to the member societies, on the basis of mutual guarantee, the extent of which is dependent on the size of the agricultural district in question.

Other articles required by the agricultural community are handled on co-operative lines, of which mention may be made of fuel and seeds.

The application of the co-operative principle to agriculture is, in Denmark, most characteristically shown in producing associations—co-operative dairies, "slaughteries" and egg collecting associations.

The Danish Co-operative Dairy Association was founded in the eighties with the object of extending to the smaller farmers the advantages to be gained from the production of milk in bulk, by improving the level and quality. The method employed is for

a number of farmers in a district to combine to erect a dairy, the capital for the construction being advanced by a local bank on the basis of the absolute liability of the interested parties. In this manner upwards of 14,000 co-operative dairies have been erected in the country which to-day handle nearly 80 per cent. of the milk output, amounting to some 3,500,000 tons per annum. The farmers, who are bound to deliver all their milk to the dairy of which they are members, are paid by the dairies on what amounts in practice to the actual butter fat contents of the milk delivered. The dairies pay all overhead charges, such as transport, so that in this respect all the members of a dairy are equally placed, whether their farm lies far from or near to the dairy. Of the butter produced in these dairies, some 30 per cent. is moreover sold by the Butter Export Association, the remainder being handled by private firms.

The 46 co-operative "slaughteries," founded on similar lines, now handle about 90 per cent. of the total bacon production of the country. The output is mainly sold through British firms, but one co-operative selling association exists comprising nine "slaughteries." The co-operative "slaughteries" also interest themselves in the improvement of the stock by the establishment of stud farms and the publication of pedigrees, etc.

As regards eggs, the Danish Joint Egg Export Company has a membership of about 500 egg associations throughout the country with some 50,000 members. These members are bound to deliver eggs stamped so that they can be traced back in case of complaint.

Further, a Joint Cattle Export Association exists embracing a number of local associations throughout the country, the members undertaking that their sale of cattle, outside their own district, shall be made through the association. The cattle in question are delivered to the society on a fixed day in the week, and the farmer receives the estimated value, less a small working commission to the association. The cattle are then sold by the association, at the best terms obtainable, and at the annual balancing of the books, the profits or losses are divided among the members in proportion to the number of beasts delivered throughout the year. (*Mutatis mutandis* a similar procedure is followed by the other co-operative selling associations, the seller receiving an amount based on periodical quotations at the time of delivery, and a share of the year's profits *pro rata* of his deliveries.)

The co-operative system is also applied in many other directions, indeed, there is practically no aspect of agricultural life in which, in some degree or other, co-operation has not been called upon to play a part. A cement and a machinery factory, electric power stations, various forms of insurance and finally a joint stock bank, with branches throughout the country, may be mentioned. In 1921 this bank had a turnover of Kr. 11,500,000, while the annual turnover of the various co-operative concerns (apart from the bank and the power stations) is estimated at about Kr. 1,500,000,000.

The question of the establishment of a shipping concern by the co-operative producing associations has recently been revived, but no definite decision has as yet been reached in the matter.

SMOKELESS FUEL.

The Department of Scientific and Industrial Research is empowered to test at the public expense plants for the low temperature carbonisation of bituminous coal. Such a test on "Parker" plant took place at the works of the Low Temperature Carbonisation Company, Barugh, Barnsley, during July last, and an elaborate report on the operation signed by the Director of Fuel Research, Dr. C. H. Lander, has been published under the authority of H.M. Stationery Office. In a prefatory note it is pointed out that no attempt is made to pronounce on the commercial possibilities of the plants tested. "The likelihood of commercial success can only finally be judged after working a plant under a steady load for a long period, and in the light of complete knowledge of local conditions, such as cost of raw material, quantity of raw material available, price and markets for products, cost of labour, etc."

The plant available at Barnsley consisted of two units, each capable of carbonising 50 tons of coal per 24 hours, and the test was carried out by the staff of the Fuel Research Station on one of these units, after it had been in continuous operation for eight days, on Dalton Main coal. After observation of the working of the retort for 48 hours had shown that steady conditions had been obtained, a test was started in which it was intended that over 100 tons of coal should be carbonised. This test, however, had to be discontinued owing to a breakdown of the exhauster plant, and on restarting shortage of coal necessitated the restriction of the test to 92 tons of coal. The coal employed was Dalton Main (Rotherham) coal, with which the Fuel Research Station has had considerable experience.

During the test samples were taken of the coal and of the products of carbonisation while the conditions of working and the labour required were carefully noted. The samples collected were all reduced as far as possible and brought to the Research Station for examination. In order to determine whether the test had been a satisfactory one a weight balance was prepared and found to show a loss of 0.48 per cent. "This, in conjunction with the thermal balance loss of 5.2 per cent., may," says the Report, "be regarded as very satisfactory."

The yields of products per ton of coal carbonised were as follows:—

Coke, 13.92 cwt.
Gas, 5,620 cu. ft., or 39.6 therms.
Tar, 18.62 gallons.
Liquor, 26 gallons.
Crude spirit, 1.78 gallons.
Ammonium sulphate, 13.55lbs.

The coke or smokeless fuel produced was of a very suitable size (1 in. to 3 in. pieces). It was not friable, and contained only 4.6 per cent. of breeze. Analysis showed that it contained rather

a low percentage of volatile matter (approximately 4 per cent.). When burnt in a household grate it was readily ignited and gave a good hot fire. This fire showed less flame than the coke cakes as manufactured at the Research Station, as was to be expected from its low content of volatile matter.

The yield of tar was high, representing 68 per cent. of that obtained in the assay apparatus. On examination this tar proved to be a normal low-temperature tar. The yield of gas was fairly high, and throughout the test varied considerably both in volume and in calorific value, owing to variations of pressure in the hydraulic main. The yield of ammonia was also fairly high. The liquor was, however, less than 6oz. strength, and it is questionable whether so dilute a liquor would justify recovery. The spirit obtained by scrubbing the coal gas amounted to 1.78 gallons per ton of coal.

The temperature of carbonisation was not uniform throughout the setting, varying from 600 deg. C. to as high as 800 deg. C. Suggestions are given in the Report for the improvement of temperature control. The amount of fuel consumed in the setting was excessively high owing to this high temperature, to insufficient heat insulation, and to badly designed combustion chambers. There is no doubt, the Report states, but that the 83.5 therms consumed per hour could be reduced considerably.

The conclusions officially drawn from the report are as follows:—

1. The throughput of the plant with all retorts working would be 50 tons per day (32 retorts), and would be in accordance with that claimed.
2. The products obtained were satisfactory in quantity and quality. The yields were on the average slightly better than those which have been obtained with similar coal on an intermediate scale at H.M. Fuel Research Station.
3. Certain defects in the plant showed themselves during the course of the trial, but it is considered that there should be no difficulty in overcoming these defects in future designs.

PINEAPPLE INDUSTRY IN SOUTH AFRICA.

South Africa is reported by the United States Trade Commissioner at Johannesburg to possess the largest industry in the British Empire for the growing and packing of pineapples. Like most fruits of a tropical or semi-tropical character, pineapples thrive in Natal, the eastern part of the Cape Province, and in certain parts of the Transvaal. The principal area, however, is in the eastern part of the Cape Province, where climatic conditions are most favourable.

The last agricultural census was taken in 1921, when there were 5,911 acres under pineapple cultivation in the Union of South Africa. In the Cape Province the area was 3,924 acres; in Natal, 1,875 acres; and in the Transvaal, 112 acres. These districts have, however, expanded considerably during the past three years.

In the Langholm estates (Cape Colony) alone, it is reported that 8,000 acres are to-day under pineapple cultivation, which is an indication of the expansion in the Cape Province. This vast plantation is served by eight miles of private railway line, which join on to the main line to Port Elizabeth, where the company which acquired the Langholm estate several years ago and which consumes its entire production of pines, has its factory.

Tinned South African pineapples are now on the English and Continental markets and have even found their way, in small quantities, to the United States and Canada. Four different pineapple products are tinned at the Port Elizabeth plant, namely, sliced, broken slices, crushed, and grated.

Extensive buildings have been designed for further expansion of the factory at Port Elizabeth to meet the growing output from the Langholm estates. The tin-making apparatus, it is reported, is capable of turning out 25,000 tins a day, and the plant now in use for cleaning, shaking, and cooking the pineapples is capable of dealing with 100 tons of pineapples daily.

It is believed that this industry will continue to progress fairly rapidly, as new markets are now being found (especially in Europe) for South-African pineapples. There is also the local market to develop, which up to this time has hardly been touched. The greater proportion of the high-grade tinned pineapples has been exported overseas, while the establishment of a local market has received little attention up to the present.

In view of the fact that climatic conditions are very suitable in the Cape Province and that the principal tinning factory has more or less guaranteed to purchase from farmers all the pineapples of a certain grade that they can produce, it is very likely that this industry will continue to expand, especially in that Province.

NORWEGIAN WHALING INDUSTRY.

The following table showing the yield of oil obtained by the Norwegian whaling industry in 1923, as compared with 1922, is taken from the annual report by the Commercial Secretary to H.M. Legation at Christiania:

	1922. Barrels.	1923. Barrels.
West Coast of Norway	5,000	8,510
Faroe Islands	4,000	5,852
Iceland	3,050	—
South Georgia	96,000	145,907
South Shetland ..	187,000	187,187
South Orkney	—	13,700
African Coast	20,000	38,885
Spain	22,940	36,506
Greenland	4,300	1,000 about
Newfoundland ..	—	1,600
Total	342,290	439,147

Journal of the Royal Society of Arts.

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FRIDAY, NOVEMBER 7, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.2.

NOTICES.

NEXT WEEK.

WEDNESDAY, NOVEMBER 12th, at 8 p.m. (Ordinary Meeting.) COLONEL R. E. CROMPTON, C.B., R.E., M.Inst.C.E., M.I.E.E. etc., "The Motor Car: its Birth, its Present, and its Future." MR. ALAN A. CAMPBELL SWINTON, F.R.S., Vice-President of the Society and Member of the Council, will preside.

PETER LE NEVE FOSTER PRIZE.

The late Mr. Reginald Le Neve Foster presented the Society with a donation of £140 for the purpose of founding a Prize in commemoration of his father, Mr. Peter Le Neve Foster, who was Secretary of the Society from 1853 to 1879.

The Council have resolved to offer the Prize cf £25 for an essay on "The Effect of Trade Union Regulations on Industrial Output."

Intending competitors must send in their essays not later than March 31st, 1925, to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C.2.

The essays must be typed or clearly written. They may be sent in under the author's name, or under a motto, accompanied by a sealed envelope enclosing the name, as preferred.

The judges will be appointed by the Council.

The Council reserve the right of withholding the Prize or of awarding a smaller Prize or smaller Prizes, if in the opinion of the Judges nothing deserving the full award is submitted.

GEORGE KENNETH MENZIES,
Secretary.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RECENT PROGRESS IN THE WOOL INDUSTRIES.

By ALDRED F. BARKER, M.Sc.

Professor of Textile Industries, University of Leeds.

LECTURE I.—*Delivered 3rd December*, 1923.

Recent progress in the Wool Industries may conveniently be studied under two heads: Raw Materials and Processes. This evening I propose dealing with the raw materials only, leaving the processes of manipulation to be dealt with next week. Before dealing with the more recent developments in sheep-breeding and wool-growing, a brief review of the progress made during the past hundred years may usefully be considered. Going back to the year 1820, it is interesting to note that both at home and abroad much attention was being given to sheep-breeding, particularly from the wool point of view. Both at home and abroad it would seem that the stimulus was the importations of merino rams from Spain. Perhaps even these importations may be traced to an earlier search for better wool-producing sheep, as some years previously the Dishley Leicester had been developed, and in several parts of the British Isles this line of improvement was being followed. But the more one becomes acquainted with what was going on in sheep-breeding circles at this time, the more one is impressed with the fact that the merino sheep and its possibilities was almost invariably the stimulus. Records still exist of this sheep being tried even as far north as the Lowlands of Scotland, and it is quite evident that the Ryeland and other Down sheep of to-day still carry the merino imprint.

The development of the merino in Australia by Captain Macarthur, of Camden Park, and the Rev. Richard Marsden is in itself almost a romance of the wool industry. From observations made in the Sydney Museum the suggestion arises that attention was first drawn to Australia as a wool-providing country owing to the accidental Mendelian dominance of the merino sheep over the East Indian (and many other) sheep. A merino ram crossed on to an East Indian ewe will apparently give progeny exhibiting marked merino wool characteristics and this—which we now recognise as Mendelian dominance—apparently caused the early settlers in Australia to think that the environment was causing a change in the wool of the very ordinary sheep towards the merino wool. This suggestion was a very happy one as matters turned out, for the determined opposition of Sir Joseph Banks to the proposals of Captain Macarthur would almost certainly have held back the development of Australia as a wool-growing continent for many years, but for the faith of the early settlers. Special recognition must be given to the manner in which Captain Macarthur "stuck to his guns," and it must have been a great satisfaction to him to live to see the Camden Park flock and other merino flocks firmly established, and such a price as 10/4 per lb. realised for the finest qualities grown (1821).

In connexion with the manufacturing of merino wool it is interesting to note that to within a few years of the present time it has been possible to speak with manufacturers who remember purchasing all their merino wool from Spain, then some years later from Saxony and Silesia, and later still from Australia. In List I the three phases of the merino wool manufacturing trade are in evidence. Thus about 1800 Spain dominates, about 1830 Germany dominates, and from 1850 onwards both countries give way to Australia. (Cape wools became a substantial importation into Britain about 1880). Not until about 1900 did importations into Britain from South America attain to large proportions. It would thus seem that Saxony and Silesia drew upon and utilised to the full the Spanish merino sheep some little time before Australia got going (probably about the time that we failed to utilise the merino sheep in its pure form in this country), but that their comparatively small production, about 1850, was swamped by the superabundance of Australian merino wool.

The Cape, about the same time as Australia, had the opportunity of introducing the merino, but either the conditions were not so favourable or there were not the sheep-breeders with the vigour of the Australian sheep-breeders. Although the Cape has for many years sent to this country non-felting and snow-white merino wools, it was only just prior to the War that a really strong endeavour was made to utilise to the full the apparent possibilities of vast stretches of land for merino sheep rearing. It would appear from recent evidence that South America had received the merino sheep from Spain earlier than either England, the Cape or Australia: the non-progressive attitude of the Spanish settlers, and probably the Spanish and British animosity, must be blamed for a better use not having been made of this.

Development and changes in the sources of the World's Wool Supply.

IMPORTATIONS INTO GREAT BRITAIN.

BALES.

Source.	1800	1830	1850	1880	1900	1913
Spain and Portugal ..	39,940	10,537	9,466	28,959	6,138	25,090
Germany	1,170	74,496	30,491	28,119	9,126	15,669
Australasia	658	8,003	138,679	863,816	1,118,895	1,289,113
Cape	..	..	19,879	190,614	102,268	395,114
South America	..	..	3,841	14,552	50,861	150,383
East Indies..	..	..	9,704	112,716	142,518	207,689
World Totals	42,440	98,818	291,161	1,484,581	1,680,869	2,346,005

Fig. 1. Camden Park Merino.

Evidence has recently been obtained showing that the bases of the merino flocks in Australia and South America were practically identical. In Fig. 1 is given a photograph of a Camden Park merino ewe taken in 1923. This merino is said to be pure-bred from the strain introduced very early in the 19th century by Captain Macarthur. In Fig. 1A is given a photograph of a

When dealing with South America, particular reference must be made to the Falkland Islands, where, under British stimulation, splendid flocks of sheep, based upon British Down types, have been developed. Thus Falkland wool is very consistent in possessing those crisp qualities specially associated with such wools as Shropshire, Southdown, etc.

Fig. 1A. Peruvian Merino.

Peruvian merino ewe imported into this country (a gift from Colonel Robert Stordy) in 1923. The two ewes appear to be almost identical, while a typical Ryeland ewe might well pass muster with either.

In view of our latter-day knowledge of genetics it is interesting to note how Darwin's demonstration of the principle of the natural selection of favourable varieties has affected sheep-breeding. The appeal to the sheep-breeder was so direct that

he may almost be charged with too slavishly accepting this as the only basis worthy of his consideration from a practical point of view. There are several references to sheep sports (or mutations) dispersed throughout Darwin literature, but it would seem that Darwin's idea that evolution was based upon the accumulation of the "fluctuation" (in a favourable direction) and not on the "sport" resulted in only casual mention of the sports which did arise, while the changes of apparently a more gradual nature were tacitly taken as proof of Darwin's idea of the "mechanism of evolution."

The work of De Vries on "mutations" and the rediscovery of Mendel's work in the early days of the 20th century appear to have supplied the stimulus which the coming of the merino gave a hundred years earlier. Under the stimulating influence of Professor Bateson and R. C. Punnett and the late A. D. Darbishire, some quite interesting work has already been carried out on Mendelian lines. The most picturesque experiment was first tried. The Suffolk sheep is hornless and has a jet-black glossy face. (Fig. II). The Dorset Horn is horned (both male and female) and has a pink-white face. (Fig. III). What better test of the truth of Mendel's ideas than to re-shuffle these "characters!" This was done and there seemed to be no difficulty in obtaining such re-combinations as a hornless sheep with a white face and a horned sheep with a black face. When the possibility of this re-shuffling was realised it was natural that Professor

FIG. II. THE HORNLESS SUFFOLK SHEEP.

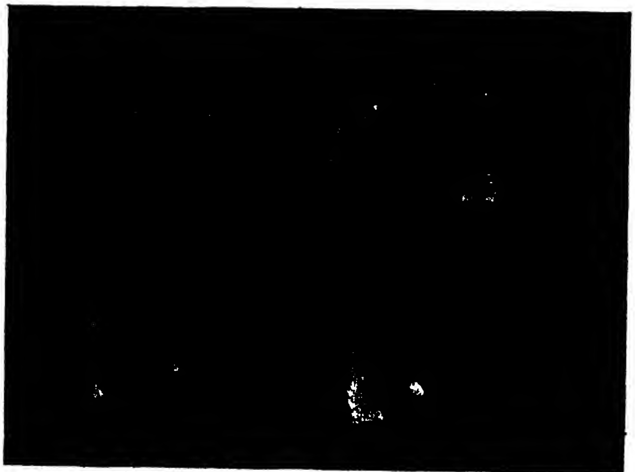

FIG. III. THE DORSET HORN SHEEP.

T. B. Wood, of Cambridge, who was specially interested in live-stock, should suggest that the attempt should be made to combine a good carcase character with a good wool character. For this purpose Australian merinos were mated with English Shropshires and eventually the cross-bred sheep was crossed with itself. Unfortunately only negative results were obtained—the large-bodied sheep always seemed to carry a coarse wool and the small-bodied sheep a fine wool. It would seem that with the particular individuals employed the linked characters of large body and fine wool were not a possibility, but there is some evidence that with other individuals these two characters may be linked together. The Corriedale and Polworth breeds of New Zealand and Australia would suggest that the wool may take on an intermediate character; but careful examination may show that this is not so. Sheep are built up of many unit characters and the re-combination to obtain the desired double-doses are a work of much difficulty in view of the usual impossibility of "seeing" half-doses in animals. There is no doubt, however, that the re-shuffling of characters brought so prominently to the fore by Mendelian research is likely to have far-reaching effects in the wool industry, for at least in some cases it will make possible the production of the double-purpose animal. A good example of this is illustrated in Fig. IV.

About ten years ago Professor J. Cossar Ewart, of Edinburgh University, put forth the idea that the present-day sheep was not

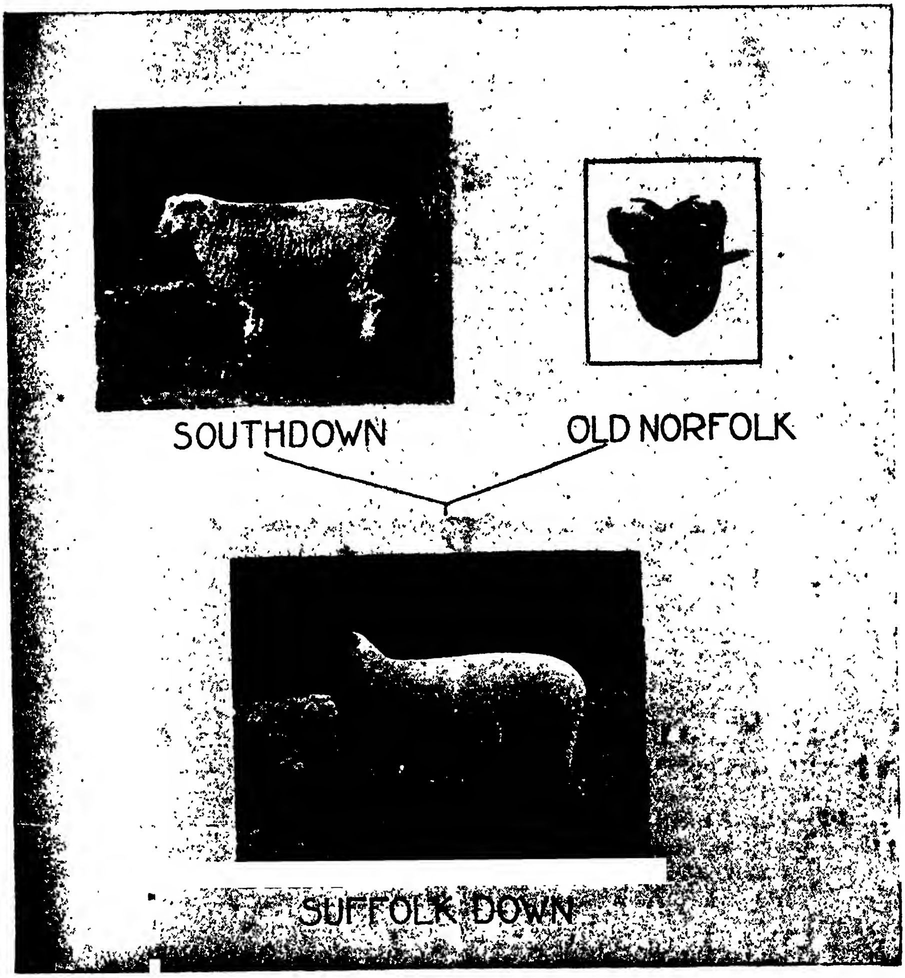

FIG. IV. ILLUSTRATING THE EVOLUTION OF THE SUFFOLK SHEEP.

descended from an unknown ancestor, but was built up on mutations from types still existing. Taking the short-tailed Soay sheep as a basis, by crossing it with the Asiatic fat-tailed sheep he showed how our present-day long-tailed sheep may have originated. Since then several examples tending to prove that this idea is correct have come to hand. In 1922, among a flock of Suffolk lambs, an almost pure fat-tailed was discovered. Again, the double coat of hair (outer) and wool (under) obtainable in the case of the wild sheep is almost invariably present in the domestic sheep. If there were an exception to this rule it would be in the case of the merino sheep, which might be supposed to have the undercoat of wool only. But this year (1923) in Australia the observation was made that all or nearly all the merino lambs examined had the double-coat, but apparently lose the outer hair coat when two or three months old. This observation has since been confirmed by Mr. Henry Robinson, of Reading Agricultural College, who reports a hair coat on most of the lambs from the Peruvian ewes presented by Colonel Robert Stordy.

In view of this work by Professor Ewart it is interesting to note that almost similar results have been obtained by Dr. J. C. Willis and Mr. G. Udny Yule, in dealing with the plants of Ceylon. When it is realised that these workers on distinctly different lines have arrived at similar conclusions, one very important question arises. If present-day variations are not descended from extinct ancestors, but are simply mutations of present-day types, then the old controversy of Special Creation *v.* Evolution is raised again, unless it should prove that in nature, as we know her, there is more than one line of evolution. If this be granted for the present period then it is further thinkable that the present-day distinct lines were evolved from one source at a far distant period.

The stimulating effect of Mendel's work is continually coming into consideration, and perhaps no more interesting case of this could be cited than the investigation at present being conducted at Leeds by the Ackroyd Fellow of the University (Mr. F. W. Dry) into the Wensleydale black problem. The typical Wensleydale blue-faced sheep produces the best lustrous wool known, this growing from the skin in long ringlet form. The sheep should have a level grey-blue face. Unfortunately this face colour is due either to a half-dose of black or to only a half-dose of black-suppressing factor: thus it is obvious that in mating such sheep many blacks are likely to crop up—from well kept records of certain Wensleydale flocks Mr. Dry places the proportion at about 15 per cent. In Wensleydale flocks at least four types of sheep are observable, viz., black (apparently a pure Mendelian recessive), silver-grey, normal and pink. The work of accounting for these types on Mendelian lines is progressing very satisfactorily, and it is thinkable that shortly methods may be discovered of differentiating the whites into heterozygous and homozygous types. From the "wool" point of view the white Wensleydale is much to be desired. Wensleydale wool gives a most beautiful waved appearance in the woven texture if this is raised wet, due to the natural ringlet form of the wool-fibre trying to re-assert itself. Much more of this type of wool will be required in the near future.

Attention may now be turned to the most recent developments in the wool-growing industry. These have followed two well defined lines, viz., developments to increase the world's supply of wool and developments to improve the quality of the wool, in view of the large demand and consequently high prices obtained for merino (*i.e.*, really of fine wool).

As already indicated, South Africa is making a very strong bid for a more important position among the world's wool-producing countries. Pedigree stock carefully selected for the prospective environment is being imported from Australia, and the figures of South African wool-production, both from the point of view of quantity and quality, will be examined with much interest by those engaged in the wool trade. Certainly African merino wools are making a name for themselves in the markets of the world.

But perhaps the most interesting development taking place at the present time is that inaugurated by the President of Peru, which is in the able hands of Colonel Robert Stordy. The base flock is the Spanish merino of a very early type (see Fig. 1A), and this is being improved in one direction towards the finer merino wool and in another direction by the introduction of British Down breeds) towards a hosiery wool of say 50s. to 56s. quality. Peruvian wools seem

to possess a peculiar handle, which makes them specially valuable for certain purposes. The sheep-farms are some 10,000 feet up the Andes, but such wonderful tracts of land are available that Colonel Stordy anticipates Peru ultimately yielding about one-third the weight of the present Australian clip.

It is interesting to note that the Crown Colony of Kenya appears to have similar lands upon which sheep will thrive, and attempts are also being made there to increase the quantity and improve the quality of the wools grown.

The demand for merino wools is having a most interesting effect in both New Zealand and Australia. The tendency towards a mutton sheep or even a dual-purpose sheep is now being seriously brought into question. Thus on recently inspecting a flock of Corriedale sheep in Australia—large sheep with heavy fleeces of a medium quality of wool—the question was asked, "Would not a better financial return have resulted from a good merino strain?" and the answer was "Yes." Now, this is due to the wonderful development of the merino in both weight of body and weight of fleece. Mr. Futter and Mr. Morrison—two of Australia's most noted breeders—recently stated in Sydney that 40% had been added to the weight of the Australian merino within the last forty years, without any sacrifice of fineness. This wonderful development of the merino must have largely suppressed the adoption of the Corriedale (Lincoln cross merino) sheep in Australia and may even attack its position in New Zealand. The most difficult thing the New Zealanders have to face, however, is the maintenance of the early maturing flocks of lambs without loss of quality in the wool; this is really a serious problem.

It is further interesting to note that in Australia attempts to increase the quantity of wool produced are also taking the line of better irrigation of desert lands and the development of the breed of sheep which makes the best use of such lands. This latter problem is by no means so easy as would appear on first thought. If, for example, a Lincoln ram be crossed on a merino ewe for producing the Corriedale type of sheep it seems that the progeny exhibit the gregarious habits of the mother (see Fig. V); while, if the cross is the reverse way, viz., merino ram on Lincoln ewe,

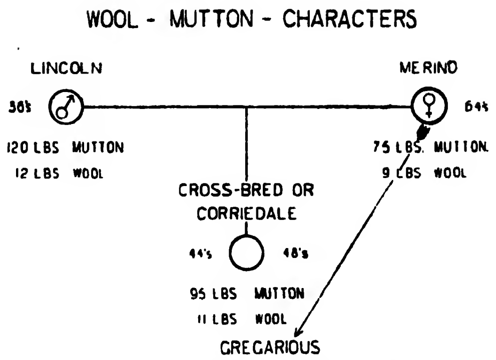

FIG. V. LINCOLN AND MERINO, GIVING THE CORRIEDALE.

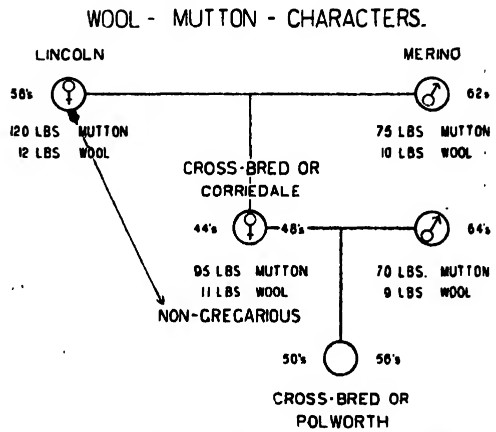

FIG. VA. MERINO AND LINCOLN CROSSED MERINO, GIVING THE POLWORTH.

the progeny, still exhibiting the habits of the mother, are non-gregarious, and thus make better use of any given tract of land. (See Fig. VA). This would appear to point to the "habits" referred to being inherited through the cytoplasm of the mother-cell. Unfortunately there may be greater difficulties in developing the VA type as against the V type.

Perhaps the most interesting attempt to improve the quality of wool is that being made in Britain. Of the 100,000,000 lbs. produced by Britain, a large portion is of the rough mountain type—Herdwick Black-face, etc. A proposal to improve the mountain wools by the introduction of merino blood was put forward by the University of Leeds, and, in view of a hardy merino obviously being most suitable, the very generous offer of Colonel Stordy of some twenty Peruvian rams and ewes has been accepted, and experiments have been started which already are promising well.

Only recently one of the best known wool-staplers of Yorkshire was criticising this experiment in total ignorance of the fact that there has been a merino flock in England (inbred) during the past forty years which still maintains its physical stamina and its fine wool characteristics. In New Zealand the merinos are in the roughest part of the country and although it is known from experience that certain types of merino will not thrive in England, there is every reason to anticipate that the Peruvian merinos, both as pure-breds and half-breds, will do well.

Reference should also be made to the attempts in certain districts of India to improve the type of wool produced. It is fairly obvious that there must be many districts in India at least as suitable for sheep as the 10,000 feet districts of Peru and Kenya, and, in view of the increasing demand of India and the East for fine wool goods, it is to be hoped that every encouragement will be given to experiments leading in this direction.

Two other fibres employed in the wool industry call for special comment—the Vicuna from the Vicuna Camel of Peru, and the Ovibos fibre from the so-called Musk-Ox of the Arctic regions.

Until quite recently the Vicuna fibre could only be procured by shooting the animal, but Colonel Stordy has crossed the Alpaca with the Vicuna, and the Leeds University tests of the fibre grown by the cross-bred animal show much of it to be almost, if not quite, up to the pure Vicuna standard. A most promising development is here being taken in hand, and along with this the Colonel is also working up a white Alpaca flock and a flock giving the peculiar waved Alpaca so much sought after.

The use of the Ovibos fibre was suggested by Mr. V. Stefansson, on returning from his Arctic exploration of 1919, and only last year the University of Leeds manufactured some of this fibre into a suiting fabric which was most graciously accepted by His Majesty the King. This fibre rivals Cashmere in fineness and should it be possible to produce large quantities of it, it is assured of a place in the wool-manufacturing world. Unfortunately, this fibre is at present only obtainable by shooting the animal, and when the leader and guardian of a flock of Ovibos is shot, this means the destruction of the whole flock. The Canadian Government, however, is moving in the matter, and it may soon be found possible to maintain large flocks of these animals under semi-domesticated conditions in the northern regions of Canada. The creature itself is very fierce and would object to shearing. Fortunately, the fibre is the "under-coat," which it sheds once a year, so that this difficulty is readily surmounted. The occasional coarse strands of the "outer-coat" found with the finer "under-coat," are, however, a greater difficulty, but no doubt these may be got rid of by mechanical means, as in the case of Cashmere.

Perhaps the most serious problem to be faced is that of bringing the wool-grower and the wool-manufacturer together. The famous example of the late Sir Titus Salt's discovery, or rather re-discovery, of Alpaca should teach a lesson, but this lesson still does not appear to have been fully appreciated. Only just recently one of the roughest of British wools, then being sold for carpet yarns to America, was converted, in the Textile Industry Department of the University of Leeds, into tweed fabrics selling at seven times the cost of the wool put into them. There is a quiet work to be done here. It is hoped that eventually so close may be the association between wool-grower and wool-manufacturer that it will always be possible for the wool-manufacturer to obtain the special wool he requires and that the wool-grower will know what wools are likely to be in demand, and thus, within natural limits, will be able to produce the most useful wool and sell to the greatest advantage.

* * *

This lecture would not be complete without some reference to the several vegetable fibres which, in view of the high price of wool, are used as cheapening agents, and to the two or three types of artificial silks which have been such a marked factor in keeping the looms of Yorkshire running.

Of the first-class, flax, hemp and jute wastes may be cited. Spun with wool on the woollen principle, some extraordinarily good yarns and fabrics have been produced. The handle, however, is never that of the "all wool" nor even that of the "mungo" fabric.

At this stage reference should also be made to the recent developments in Colonial cotton-growing. Australia looks at her return of £40,000,000* for her wool

* Said to be possibly £70,000,000 for the year 1924.

clip and then at the United States' return of £400,000,000 for her cotton crop, and dreams of cotton. Although Australian cotton so far is too short for the wool manufacturer, it is possible that it may be improved in length, or it is conceivable that the provision of this cotton might release some of the longer cotton for the wool manufacturers' use.

The artificial silks have been employed in the pure state, but more frequently with natural silk, or cotton, or wool yarns, these latter usually as warp. Most beautiful fabrics have thus been produced which redound to the credit of Yorkshire manufacturers. Perhaps one of the most difficult problems to be found has been the utilisation of artificial silk wastes. Even this is now successfully attempted. Thus the Yorkshire manufacturer, with all his shortcomings, has to his credit the first successful utilisation of many of the new fibres in the past and is still maintaining his progressive and wide outlook.

LA VIE INDUSTRIELLE EN FRANCE.

LE XIX° SALON DE L'AUTOMOBILE.

(Paris, Octobre, 1924.)

Le Salon annuel de l'Automobile s'étend actuellement sur deux périodes, car le Grand-Palais des Champs-Elysées n'est plus assez grand pour abriter la production des constructeurs français et étrangers. La première période, la plus importante d'ailleurs, réservée aux voitures de tourisme, vient de se terminer sur un éclatant succès, et près de 120 constructeurs de voitures y étaient représentés, sans parler des innombrables fabricants d'accessoires divers.

Les progrès de la construction sont aujourd'hui assez affirmés pour qu'il ne se manifeste guère de nouveautés de principe, mais les constructeurs ont encore fort à faire pour mieux étudier et généraliser l'emploi de dispositifs qui étaient, hier encore, considérés comme un luxe, et qui demain seront des organes indispensables à toute bonne voiture : démarrage électrique, freins avant, gonfleurs de pneus, etc.

Les perfectionnements aux moteurs ne s'arrêtent pas non plus, et la création récente de deux autodromes dont l'un tout près de Paris, est de nature à faciliter beaucoup la mise au point des chassis, en permettant les essais à toute vitesse, sur une piste en ciment parfaitement installée, infiniment plus commode et plus sûre que les routes publiques.

L'impression générale qui se dégage du Salon de cette année est que les constructeurs concentrent leur activité sur un nombre réduit de modèles, parfois même un seul modèle en deux grandeurs, comme Citroën qui fabrique exclusivement des modèles 10 h.p. et 5 h.p. La plupart, d'ailleurs, ont un chassis 10 h.p., qui est le plus courant et le plus demandé par la clientèle moyenne.

Comme modèle plus important et plus luxueux, on trouve, dans de nombreux stands, les chassis à moteurs de 2 litres de cylindrée, qu'on désigne plus couramment par l'expression "Chassis deux litres." Avec de tels moteurs, qui donnent effectivement une cinquantaine de chevaux, on peut circuler à 100 kilom-heure, en emmenant quatre voyageurs et en consommant 12 à 15 litres d'essence par 100 kilomètres. Un chassis de ce type pèse environ 1,000 kilogrammes. Au sujet des moteurs, il est à noter que tous les nouveaux modèles sont munis de soupapes dans la culasse, les moteurs sans soupapes conservent leurs partisans, qui sont peu nombreux, mais qui sont de premier ordre : Panhard et Levassor, notamment, n'en emploie pas d'autres.

Le nombre d'automobiles en service en France actuellement est d'environ 550,000. Il semble devoir augmenter rapidement, car la clientèle se multiplie, même dans les classes modestes. La production de l'année prochaine peut-être prévue d'au moins 200,000 voitures, dont la plus grande partie sera absorbée par la clientèle française.

CABLES TRIPHASES A ENVELOPPE METALLISEE POUR TENSIONS ELEVEES.

Un câble triphasé ordinaire comprend 3 conducteurs recouverts de papier, juxtaposés avec interposition de jute, et enfin enveloppés d'une ceinture de papier. Après séchage et imprégnation d'huile, le tout est enfermé dans une gaîne en plomb.

Le nouveau type de câble, dit métallisé, que fabriquent les Ateliers de Jeumont, en France, et ceux de Charleroi, en Belgique, est caractérisé par les perfectionnements suivants :

Chaque conducteur, recouvert de papier, est entouré d'une bande de papier doublé d'une mince pellicule d'aluminium. Les trois conducteurs sont alors assemblés, avec interposition de jute, et maintenus mécaniquement à l'aide d'une toile ; puis, après le séchage et l'imprégnation d'usage, le câble est recouvert d'une gaîne de plomb.

De nombreux fils de cuivre sont noyés dans la trame de la toile qui maintient pendant la fabrication les trois torons assemblés. Ces fils ont pour but d'assurer le contact électrique des papiers métallisés et de la gaîne de plomb, entre lesquels la différence de potentiel doit être nulle.

L'avantage que présentent ces papiers métallisés recouvrant ainsi chaque toron isolé est double :

1°—Ils diminuent la résistance thermique du câble et permettent d'accroître l'intensité de courant admissible, sans que la température de régime devienne dangereuse pour l'isolant. Ces pellicules métalliques transmettent, en effet, à la gaîne de plomb la chaleur développée par effet Joule à l'intérieure du câble. De ce fait, pour une même température de régime, la densité de courant du câble "métallisé" peut dépasser de 25 à 30 % celle d'un câble ordinaire ; 2°—Chaque conducteur

entouré de son papier et de son feuillard d'aluminium mis à la terre, constitue un câble monopolaire; or, celui-ci, sollicité par un champ électrostatique radial, présente une résistance supérieure, à égalité de fatigue, au câble triphasé soumis à un champ complexe et variable.

En outre, le champ électrostatique est limité dans le câble métallisé entre le conducteur et la pellicule d'aluminium. Dès lors, les jutes et la toile qui, même imprégnés, constituent des matériaux plutôt inférieurs au point de vue rigidité diélectrique, échappent aux phénomènes électrostatiques. De cette répartition du champ dans le câble métallisé, il résulte que l'on peut diminuer l'épaisseur du diélectrique.

Ces avantages sont d'autant plus marqués qu'il s'agit de câbles destinés à des tensions plus élevées, à partir de 30,000 à 35,000 volts, par exemple.

LES RESSOURCES DE L'INDUSTRIE PAPETIÈRE FRANCAISE.

L'industrie papetière française est fortement concurrencée par les importations étrangères, soit de papier, soit de pâte de bois, en provenance des Pays scandinaves, de l'Allemagne, de la Finlande, de la Suisse et de la Tchèco-Slovaquie.

Le total de ces importations, pour le papier seulement, dépasse annuellement 100,000 tonnes. Cette situation provient pour une grande part de ce que les papetiers francais produisent trop peu de pâte, et travaillent principalement les pâtes importées.

Pour fabriquer de la pâte à papier avec des végétaux existant en France, deux procédés ont été récemment imaginés: le traitement des pins par le sulfate de soude, et celui des pailles de céréales par le procédé au chlore et à la soude combinés.

Le procédé au sulfate de soude est excellent pour le traitement des pins maritimes, si abondants dans la région des Landes, en vue de fabriquer les papiers d'emballage, dont on importe environ 1,000 tonnes par mois en France.

L'autre procédé utilise l'électrolyse du chlorure de sodium, qui donne à la fois de la soude et du chlore, facile à transformer en chlorure de chaux: or, la soude et le chlorure de chaux sont les deux produits nécessaires à la fabrication de la pâte dite à la soude. Mais l'électrolyse donne beaucoup plus de chlore qu'il n'en faut pour blanchir la pâte obtenue avec la soude fabriquée simultanément; il faut donc, ou perdre cet excès de chlore, et alors l'opération n'est plus économique, ou l'employer accessoirement à blanchir de la pâte d'une autre provenance, ou enfin utiliser le procédé de Vains, dans lequel l'action du chlore se substitue en partie à celle de la soude, et, où, par conséquent, on emploie moins de soude et plus de chlore, ce qui rétablit à peu près l'égalité entre les productions et les consommations.

Les meilleurs résultats avec le procédé de Vains ont été obtenus, jusqu'ici avec l'alfa et avec les pailles de blé, de seigle et de riz. Or, l'alfa est abondant en Algérie, et les pailles de céréales se trouvent également un peu partout en France.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at 8 o'clock, unless otherwise announced):—

November 12.—Colonel R. E. Crompton C.B., R.E., M.Inst.C.E., M.I.E.E., etc., "The Motor Car: its Birth, its Present, and its Future." Alan A. Campbell Swinton, F.R.S., will preside.

November 19.—Llewelyn B. Atkinson, M.I.E.E., Past-President of the Institution of Electrical Engineers, "The Scientific Principles of Artificial Incubation." Edward Brown, F.L.S., President of the International Association of Poultry Instructors and Investigators, will preside.

November 26.—C. F. Elwell, B.A., "Talking Motion Pictures."

December 3.—Professor C. A. Carus Wilson, M.A., F.R.A.S., "The Teaching of Science in Secondary Schools." Sir Robert Abbott Hadfield, Bt., D.Sc., F.R.S., will preside.

December 10. (5.0 p.m.). — Norman Thomson, "Colombia as a Field for Development."

Dominions and Colonies and Indian Sections: Joint Meeting.

Tuesday, November 25, at 4.30 p.m:— Lord Stevenson, G.C.M.G., "The British Empire Exhibition, 1924." Sir Charles Campbell McLeod will preside.

Indian Section.

Friday Afternoon, at 4.30 o'clock:—

December 5. — Lieut.-Colonel R. McCarrison, C.I.E., M.D., B.Ch., B.A.O. (R.U.I.), LL.D., D.Sc., F.R.C.P., Indian Medical Service, "Problems of Food, with Special Reference to India." Professor Henry E. Armstrong, Ph.D., LL.D., D.Sc., F.R.S., will preside.

Papers to be Read after Christmas.

Sir Ernest Rutherford, M.A., D.Sc., F.R.S., *Trueman Wood Lecture.*

Sir J. Fortescue Flannery, Bt., Past-President of the Institute of Marine Engineers, "The Diesel Engine in Navigation." Lord Bearsted will preside.

Sir Dugald Clerk, K.B.E., D.Sc., F.R.S. Subject to be announced later.

Major-General Sir William Sefton Brancker, K.C.B., Director of Civil Aviation, Air Ministry, "Commercial Aviation."

J. S. Owens, M.D., A.M.I.C.E., F.G.S., Superintendent Advisory Committee on Atmospheric Pollution, Air Ministry, Meteorological Office, "Modern Atmospheric Conditions."

Sir Samuel Instone, "The Thames Passenger Services."

Cedric Chivers, "Bookbinding."

Professor W. E. S. Turner, O.B.E., D.Sc., F.Inst.P., Department of Glass Technology, University of Sheffield, "The Modern Production of Sheet-glass."

C. R. Peers, C.B.E., F.S.A., Chief Inspector of Ancient Monuments and Historic Buildings. Subject to be announced later.

Lieut.-Colonel Andrew Balfour, C.B., C.M.G., M.D. (Edin.), B.Sc., D.P.H., F.R.C.P.E., "The Trend of Modern Hygiene."

Mrs. Graydon-Stannus, "Irish Glass, Old and New."

Charles A. Baker, Engineering Department, London County Council, "The Electrical Equipment of the London County Hall."

Emile Cammaerts, "The Restoration of Public Buildings in Belgium."

Lieut.-Colonel Sir David Prain, I.M.S., C.M.G., C.I.E., M.A., M.B., LL.D., F.R.S.E., F.R.S., *Sir George Birdwood Memorial Lecture*, "Government Botanical Gardens."

J. T. Marten, M.A., I.C.S., "The Indian Census."

Sir Henry Sharp, C.S.I., C.I.E., M.A., "The Development of Indian Universities."

Sir Gilbert T. Walker, C.S.I., M.A., F.R.A.S., Sc.D., Ph.D., F.R.S., "Indian Meteorology."

Sir Alfred Chatterton, C.I.E., Assoc.M.Inst.C.E. Subject to be announced later.

Hon. William G. A. Ormsby-Gore, M.P. Subject to be announced later.

Lord Blyth, "Penny Postage and Postal Communications Generally."

Brigadier-General Sir Percy M. Sykes, K.C.I.E., C.B., C.M.G., "The Heart of Asia and the Roof of the World."

Cantor Lectures.

Monday evenings, at 8 o'clock.

Louis C. Martin, D.I.C., A.R.C.S., D.Sc., Lecturer in the Department of Optical Engineering and Applied Optics, Imperial College of Science and Technology, South Kensington, "Modern Colour Problems." Three Lectures. November 24, December 1 and 8.

Lecture I.—The relations of light and colour. The physical basis of colour vision. The production of artificial daylight. Early efforts and modern improvements. The application of artificial daylight for time saving in industry.

Lecture II.—The psycho-physical basis of colour measurement. Specification of colour in terms of three variables. Colour systems and charts. Definite problems in colour measurement and their importance in Commerce.

Lecture III.—Colours of material objects. Some colorimeters and their possible accuracy. Limited range colorimeters and nephelometers. General lines of progress. Probable limitations of these methods.

V. E. Pullen, Director, Radiological Research Department, Woolwich, "Radiological Research — A History." Three Lectures. January 19, 26, February 2.

Lecture I.—Natural Philosophy. The Fascination of speculative philosophy. The border line between science and philosophy. Early natural philosophy. Development of theory. Discovery of X-rays. Controversy as to their nature. Modern theory concerning X-rays. Relation to modern atomic theory.

Lecture II.—Early apparatus. Early X-ray generators. Early vacuum tubes. X-ray tubes. Development of electrical generators. Development of X-ray tubes. The X-ray spectrometer. Measuring apparatus. Lines of modern radiological research.

Lecture III.—Early applications of X-rays. Development of medical uses. Modern applications. Physiological dangers. Necessity for protection.

Walter Rosenhain, B.A., B.C.E., D.Sc., F.R.S., Superintendent of the Department of Metallurgy and Metallurgical Chemistry at the National Physical Laboratory, "The Inner Structure of Alloys." Three Lectures February 16, 23, March 2.

Howard Lectures.

Professor John Samuel Strafford Brame, F.I.C., F.C.S., late President of the Institution of Petroleum Technologists, "Motor Fuels." Three Lectures. April 20, 27, May 4.

Dr. Mann Juvenile Lectures.

Wednesday afternoons, at 3 o'clock.

Lieut.-Colonel G. M. Richardson. Two Lectures.

Lecture I.—January 7.—"Dogs in War."

Lecture II.—January 14.—"Dogs in Peace."

(Special tickets are required for the Dr. Mann Juvenile Lectures.)

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, NOVEMBER 10 .. Geographical Society, Lowther Lodge, Kensington Gore, S.W., 5 p.m. Major R. W. G. Hingston, "Physiological Difficulties in the Ascent of Mount Everest."

Metals, Institute of, (Scottish Section), 39, Elmbank Crescent, Glasgow, 7.30 p.m. Mr. C. E. Henshaw, "An Outline of the Process of Casting in Bronze by the 'Cire Perdue' Method."

Electrical Engineers, Institution of, (Informal Meeting), Savoy Place, Victoria Embankment, W.C., 7 p.m. Mr. P. Dunsheath, "Research in the Cable Industry."

(North Eastern Centre), Armstrong College, Newcastle-on-Tyne, 7.15 p.m. Mr. S. C. Bartholomew, "Power Circuit Interference with Telegraphs and Telephones."

University of London, King's College, Strand, W.C., 5.30 p.m. Dr. R. W. Seton-Watson, "Austria-Hungary in 1867-1918." (Lecture VI.)

People's League of Health, at the Medical Society of London, 11, Chandos Street, W., 6 p.m. Sir Maurice Craig, "The Mind and What we ought to know about it." (Lecture IV., "Habit and Adaptation.")

Surveyors' Institution, 12, Great George Street, S.W., 8 p.m. Presidential Address.

Brewing, Institute of, at the Engineers' Club, 39, Coventry Street, W.C., 7.30 p.m. Mr. A. Charton Chapman, "Preservative Properties of Hops."

TUESDAY, NOVEMBER 11 .. Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 7 p.m.

Anthropological Institute, 50, Great Russell Street, W.C., 8.15 p.m.

University of London, King's College, Strand, W.C., 5.30 p.m. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture VI.)

5.30 p.m. Dr. H. W. Carr, "The Philosophy of Bergson: its relation to Past Systems and to Present Science." (Lecture VI.)

Photographic Society, 35, Russell Square, W.C., 7. p.m. Mr. L. B. Booth, "Traill-Taylor Memorial Lecture."

Roman Studies, Society for the Promotion of, at the Society of Antiquaries, Burlington House, Piccadilly, W., 4.30 p.m. Discussion on the "Antioch Chalice."

Asiatic Society, 74, Grosvenor Street, W., 4.30 p.m. Dr. M. Gaster, "Indian Tales in Jewish Literature."

WEDNESDAY, NOVEMBER 12 . Electrical Engineers, Institution of, (South Midland Centre), The University, Edmund Street, Birmingham, 7 p.m. Discussion on the New I.E.E. Wiring Regulations (Buildings).

Royal Academy, Burlington House, Piccadilly, W., 4 p.m. Dr. A. P. Laurie, "Early Methods of Oil Painting."

University of London, University College, Gower Street, W.C., 5.30 p.m. Mr. I. C. Grøndahl, "Nature Feeling in Norwegian Literature." (Lecture I.)

5.30 p.m. Mr. G. F. Barwick, "The British Museum Library." (I. The Reading Room.)

At the School of Oriental Studies, Finsbury Square, E.C., 5 p.m. Rev. W. S. Page, "Ballads of Eastern Bengal."

Public Health, Royal Institute of, 37, Russell Square, W.C., 4 p.m. Colonel Sir Leonard Rogers, "Leprosy as an Imperial Problem."

THURSDAY, NOVEMBER 13 .. Engineering Inspection, Institution of, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m. Mr. A. P. Welch, "The Development of Long and Short Wave Wireless Signalling."

Gilbert and Sullivan Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 8 p.m.

Aeronautical Society, 7, Albemarle Street, W. Prof. L. Bairstow, "Skin Friction."

Royal Society, Burlington House, Piccadilly, W., 4.30 p.m.

Textile Institute, 38, Bloomsbury Square, W.C., 5.45 p.m. Mr. J. S. M. Ward, "Textile Fibres produced within the Empire."

Metals, Institute of, at the Royal School of Mines, South Kensington, S.W., 7.30 p.m. Prof. H. Turner, "The Oxidation of Metals, with special reference to Thin Films."

Geffrye Museum, Kingsland Road, E., 7.30 p.m. Mr. E. Gribble, "Mediæval Woodwork."

Child Study Society, 90, Buckingham Palace Road, S.W., 6 p.m. Commandant Mary Allen, "Women Police Work among Children."

Royal Academy of Arts, Burlington House, Piccadilly, W., 4 p.m. Dr. A. P. Laurie, "Modern Pigments: their Proper Selection and Use."

University of London, University College, Gower Street, W.C., 5.30 p.m. Dr. C. Pellizzi, "La dottrina sociale e storica di G. B. Vico." (In Italian.)

At King's College, Strand, W.C., 5.15 p.m. Mr. F. J. C. Hearnshaw, "Social and Political Ideas of some Great Thinkers of the Renaissance and Reformation." (Lecture IV.) "Nicolo Machiavelli."

5.30 p.m. Mr. E. Prestage, "Luis de Camões; his Life and Lusiads."

5.30 p.m. Prince D. S. Mirsky, "The Russian Novel from Turgenev to Chekhov." (Lecture VI.)

At Bedford College for Women, Regent's Park, N.W., 5.15 p.m. Prof. W. Wilson, "Atomic Structure and Quanta."

Mechanical Engineers, Institution of (North-Western Section), Engineers' Club, Albert Square, Manchester, 7.15 p.m. (Graduates' meeting.) Mr. F. W. L. Heathcote, "Involute Gearing."

Royal Historical Society, 22, Russell Square, W.C., 5 p.m. Prof. P. Geyl, "William IV. of Orange and his English Marriage (1734—1751)."

FRIDAY, NOVEMBER 14 .. London Society, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5 p.m. Dr. S. Sunderland, "Old London's Spas and Wells."

Central Asian Society, at the Royal United Service Institution, Whitehall, S.W., 5 p.m.

Royal Academy of Arts, Burlington House, Piccadilly, W., 4 p.m. Dr. A. P. Laurie, "Painting Media: Oils, Varnishes and Tempera."

Astronomical Society, Burlington House, Piccadilly, W., 5 p.m.

Metals, Institute of (Local Section), University College, Singleton Park, Swansea. Dr. W. Rosenhain, "The Inner Structure of Alloys."

University of London, King's College, Strand, W.C., 5.30 p.m. Dr. O. Vočadlo, "Three Champions of Bohemian Reformation." (Lecture II.)

5.30 p.m. Prof. L. T. Hobhouse, "Scientific Method."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Mr. G. Avenall, "Round about Swanage."

Mechanical Engineers, Institution of (Yorkshire Branch), Philosophical Hall, Park Row, Leeds, 7.30 p.m. Eng. Vice-Admiral Sir George G. Goodwin, "The Trend of Development of Marine Propelling Machinery."

At Storey's Gate, London, S.W., 7 p.m. (Informal meeting.) Discussion on "Driving Belts and Ropes."

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FRIDAY, NOVEMBER 14, 1924.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2)

NOTICES.

NEXT WEEK.

WEDNESDAY, NOVEMBER, 19th, at 8 p.m. (Ordinary Meeting.) LLEWELYN B. ATKINSON, M.I.E.E., Past-President of the Institution of Electrical Engineers, "The Scientific Principles of Artificial Incubation." MR. EDWARD BROWN, F.L.S., President of the International Association of Poultry Instructors and Investigators, will preside

CHAIRMAN'S INAUGURAL ADDRESS.

The Chairman's Inaugural Address, which had to be postponed owing to the unavoidable absence abroad of Senatore Guglielmo Marconi, G.C.V.O., LL.D., D.Sc., will be delivered on Thursday, December 11th, at 8 p.m.

The subject of the Address will be announced later.

The Swiney Prize and the medals awarded for papers read during the past session will be presented.

Tea and coffee will be served in the Library after the meeting.

REPRINT OF CANTOR LECTURES.

The Cantor Lectures on "A Study of the Destructive Distillation of Coal," by Edward Victor Evans, O.B.E., F.I.C., Chief Chemist and Products Manager, South Metropolitan Gas Company, have been reprinted from the *Journal*, and the pamphlet (price 2s.) can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.

A full list of the lectures which have been published separately and are still on sale can also be obtained on application.

PROCEEDINGS OF THE SOCIETY.

CANTOR LECTURES.

RECENT PROGRESS IN THE WOOL INDUSTRIES.

By ALDRED F. BARKER, M.Sc.,

Professor of Textile Industries, University of Leeds.

LECTURE II.—*Delivered 10th December*, 1923.

Having reviewed the recent progress made in the provision and utilisation of the raw materials of the wool industries, attention may now be directed towards recent progress in the processes of manufacture. Before dealing with these in detail some attention must be given to the "standard of intelligence" observable in the industry, for upon this much depends. It has been said that "the practical man is the man who perpetuates the errors of his forefathers;" and although there may be some truth in this there is more truth in the saying that "the successful man is the man who perpetuates the successes of his forefathers." In fact, so true is the latter saying that there are still many engaged in the textile industries who stake everything upon immediate and direct personal experiences, handed on, say, from father to son, and who are almost incapable of profiting indirectly from the experiences of others. Within very restricted limits these men are usually successful; and as industry in the past has been exercised within such limits, this type of man in the past has been very successful. Hence we are continually coming across the successful business man who started as the "half-timer" or at some such lowly level, and, without schooling, has risen to the top. But capacities which would score success fifty years ago are totally inadequate for success to-day: to-day the direct experiences of the large controller of industry need the flash-light of science upon them to reveal their potentialities. Further, the controller needs

training in that logical and sequential reasoning which renders much more extensive lines of control easily manageable; and he also requires that immensely useful capacity of interpreting correctly and using to the greatest advantage, through his own experiences, the experiences of others, thus, perhaps, tenfolding his own inherent potentialities. To put the matter briefly, a different standard of intelligence is needed in the industry of to-day as compared with fifty years ago if progress is to be maintained. Where could the manufacturer be found even twenty-five years ago who could gain the faintest glimmering of such uses of nomography as those introduced into the University of Leeds by Dr. Brodetsky; or, what manufacturer would have considered for one moment such researches upon the evaporation of water from wool—in some cases a single wool fibre only being dealt with—as those recently conducted at Leeds by Messrs. E. A. Fisher and G. Barker? But it is possibly true that the capacity for gaining the scientific outlook required to-day is in inverse proportion to the driving-force outlook of the past—this probably explaining why, for the time being, the British manufacturer is lagging behind his continental competitor—the Frenchman more particularly. But such institutions as the University of Leeds are out to change all this. Thus, while recognising that the "researcher"—the specially gifted and well-trained man (or woman)—is to-day a necessity, it has equally to be recognised that a high standard of intelligence throughout the industry is extraordinarily important. Industry advances in broad sweeps as well as by taking new directions.

Perhaps before dealing with particular processes, the uses of the sciences—particularly mathematics, physics and chemistry—may briefly be referred to. Broadly these uses run upon two lines—(*a*) As aids to the better understanding of actual processes, and (*b*) as aids to the organisation and control of processes of manufacture.

Many facts observed in textile manufacturing cannot be understood without scientific insight, but once understood are not only more surely held, but may form the basis for further advances.

Again, any organisation other than the simplest cannot well be controlled without the use of mathematics in one form or another. If the slide rule, graphs and all systematic recording methods were eliminated, what possibilities of progress would there be to-day?

Of advances in processes which are being made to-day the following are noteworthy:—

Worsted Drawing Processes. These are now being based on the movement, control during movement, and arrangement of the fibres, composing the worsted sliver. Thus, the slow building-up of direct experience is being speeded up by scientific insight.

Twisting for (a) Fibre Control and (b) for Maximum Strength. The effects of twist are being investigated and the results so far achieved are proving most useful. Defining twist by the exterior fibre angle formed with the length of the thread, it is now possible to define within reasonable limits twists for fibre control and twists for maximum strength of yarns. Frictional co-efficients have yet to be taken into account, but already marked advances have been made in scientific yarn construction.

In yarn analysis the most useful recent discovery is the ease with which the twists in single yarns may be ascertained or defined by the accurate measurement of the expansion or contraction during untwisting or twisting. A simple instrument, based on a tenfold multiplication of the expansion or contraction of a thread, recently designed in the University of Leeds, bids fair to revolutionise single-twist testing in the works. This work had not proceeded far, however, before certain problems arose which both for their definition and elucidation required the easy use of the calculus.

Cloth Structures. If yarn structures are being more scientifically investigated, much more are cloths being so treated. Every year the tendency to regard a fabric as a "mass of balancing strains" is being emphasised, with the result that not only is the making of all the standard fabrics better understood, but ideas for new interlacings or "strainings" are continually coming up. Thus, fabric in which both warp and weft deviate from the straight line, in imitation of knitted effects, are now readily produced.

Finishing Processes: Not less interesting are the effects observed during the "finishing" operations. Examination of the wool-fibre by polarised light shows fibre-strains varying very considerably in the different wool-qualities. Thus, fibre, thread and interlacing or fabric strains

have to be dealt with by the finisher and play a most important part in producing, for example, the dull, crimped surface of the "crape" cloth as against the bright, smart surface of the "satin" cloth. These strains in their various combinations are the basis of "texture," and when the French manufacturer successfully competes with the British manufacturer it is because he has taken the trouble to train himself so that he has that scientific insight which will enable him to control strains in his cloths to the very best advantage.

This problem, however, is further complicated by the vagaries of fashion so far as women are concerned. So long as the present simple dress prevails British goods will hold their own, but if—to exaggerate for a moment—the crinoline were again to come into fashion, then a fabric about one-quarter the weight per area of the present fabric would be demanded, and as the French are much finer spinners than the British, a most serious blow to British trade would follow. This, perhaps, is the tendency most seriously to be apprehended and guarded against at the present moment by the introduction of more French drawing and mule and ring spinning into the British manufacturing districts.

Mechanical Developments. The call for the same scientific insight is evident in dealing with the mechanical side of the industry as on the cloth structure side. Thus one engineer will design, say, a fancy lever for the back-rest of a loom, which looks nice, but does not act correctly; while another engineer will first clearly visualise the problem and then make the lever to give the exact effect required. Slowly, but we hope surely, our textile engineers are realising the necessity for sound theory as a basis for sound practice, and if it be still true that much spinning and weaving machinery in its design still leaves much to be desired, it is equally true that marked advances are being made.

The Distribution of the Wool Manufacturing Industry.

The past, present and prospective distribution of the wool industry forms a study of quite-out-of-the-common interest. Recognising that weaving skill has come to us from the East, it is not astonishing to find after careful study that before the coming of the spinning-frame and the power-loom, skill in craftsmanship increased, as one travelled eastward. Flanders and the Rhine Valley, for example, were markedly ahead of Britain in the production of the finest and best textures, with perhaps the one or two notable exceptions where we had learnt our lesson well from our political or religious refugee teacher. Thus up to the mechanical era the line of skill seems to have been pretty much the line of the eastward migration of man, in the inverse direction.

With the coming of iron and coal, however, at least "economic production" centred in Britain and radiated outwards, naturally taking its chief line of development back along the line of migration already referred to. Whether this tendency will seriously reach so far as India, China and Japan remains to be seen. So far as the employment of mechanical means is concerned, this is already happening, and it is already thinkable that these countries may ultimately direct their known manipulative skill along mechanical lines.

But the most important migration of the mechanical industry is forward into America and to Australia. In view of the demands of the more recently settled countries for the simpler types of fabrics, this mechanical development was easily to be foreseen. Possibly an equally interesting development is that of one of the oldest of these countries—the United States of America—along the line of more complexity and greater subtlety in textile manufacturing. It is fair to say to-day that in both silk and wool America can achieve the possible—she can make the very best possible of either of these materials, although, of course, just like Europe, she does not always succeed in achieving this ideal.

Granted then that perfection of production is equally open to all, save with reference to those natural conditions over which man has little or no control—conditions which also condition those subject to them—the question may be asked, "What will be the distribution of the wool industry in the future?" Perhaps more particularly from Britain's point of view the question may be asked, "Are the agricultural tracts of the world going to manufacture for themselves, and are the specialised manufactured products of Britain going to be a drug upon the world's markets?" This latter question, and indirectly the former question, is perhaps best answered by graphing (see Fig. II) the production of

the necessaries of life—food, shelter, clothing—and the interchange of certain of these necessaries on the lines of specialised production; *i.e.*, suppose in this case that Britain, man for man, can naturally produce twice as much clothing as, say, Australia, and, conversely, Australia, man for man, can produce twice as much food. Then it is obvious that anything that stands in the way of free interchange is good for neither country. But suppose that one country, say, Australia, does pass legislation which stands in the way of free interchange, then what happens to (*a*) herself and (*b*) Britain? Before adjustment takes place Australia will be producing too much food and Britain too much clothing. This would seem to be pretty much the state of things at the present moment. The adjustment will naturally be for Britain to turn some of her skilled producers of clothing into unskilled producers of corn, and for Australia to turn some of her skilled producers of corn into less productive producers of clothing—to the disadvantage of both nations, unless one of the nations is free to deal with other nations. This, of course, is the position occupied by Britain; so that it would seem that Britain's free trade policy cannot be wrong for her. On the other hand, it does seem as though legislation was actually desirable in the case of newly developed countries to "try out" if they have the capacity for economic production. If this be admitted then no better case can be cited than that of Australia attempting to manufacture her own wool into cloth—wool which otherwise must be shipped to Europe for manufacturing and then be re-shipped back to Australia as cloth. It is furthermore arguable that a country should try to legislate with the object of employing its citizens in congenial occupations, and it is thinkable that among the many migrants to Australia there will be some who best respond to the manufacturing life. But, perhaps, the question may then be asked—Would these not find their particular vocation without legislation? Possibly they would, but there does at least appear to be some excuse for legislation such as that at present being enacted by Australia.

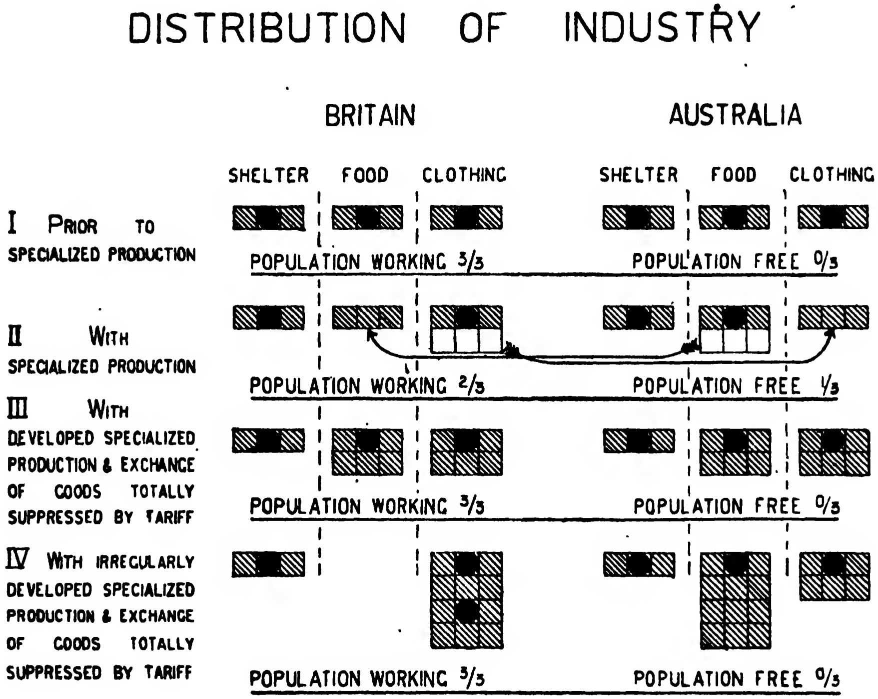

FIG. 6.

The graphical method of investigating these important problems, here shown very briefly in Fig. VI, is well worth applying much more extensively, leading to clear vision with reference to such matters as the prospective re-distribution of the textile industry the world over.

In Fig. VI the basis is the production of shelter, food and clothing with reference to a manufacturing and comparatively non-food-producing country (Britain) and a food-producing and comparatively non-manufacturing country (Australia).

In I the distribution prior to specialisation of production is illustrated; each country by the work of its whole population is able to support itself with the bare necessaries of life.

In II Britain is shewn to be producing no food, but one-third of its population is producing double the clothing required. This it is exchanging for food with Australia, which is producing no clothing, but one-third of its population is producing double the food required. In this case there is no increase in the "standard of living," but one-third of the population is freed to develop the Arts of Life (or may be regarded as unemployed), or the whole population need only work two-thirds of its time, thus gaining some leisure.

In III the effects of a tariff totally suppressing exchange of goods is shewn along with the prospective advantages of specialised production. In this case both Britain and Australia are supposed to have doubled the food and clothing production, and as a consequence there is no advantage to either to exchange—in fact, it is probable that this condition would of itself, without a tariff, have resulted in little or no interchange of commodities. It will be noticed that the whole population in each country is fully employed—there being no free time and no leisured class—but both are better fed and better clothed than under I.

In IV irregularly developed specialised production is illustrated with any mutually advantageous levelling up totally suppressed by tariff. Britain is shewn as just housing herself, producing no food, but producing much more clothing than she requires (or can afford to wear), while Australia is producing four times as much food as she requires and twice as much clothing as is absolutely necessary. Thus Britain will be starving and over-clothed while Australia will be wallowing in food and well clothed. If these circumstances actually prevailed, Britain would, of course, be famine stricken and Australia would either freely send to her relief her surplus food, or, perhaps better still, remove Britain's population to Australia until the condition shown in I prevailed in Britain. This sort of adjustment undoubtedly does go on, but the fact that Britain is not yet producing food under the conditions shewn in I is suggestive.

But the question may now be asked, Will there not be over-production of clothing in Great Britain and food in Australia, and will not this naturally adjust itself by some of Britain's population going on to the land and producing food, and some of Australia's population leaving the land and becoming an army of unemployed ?

One other use of this graphical method may be noted. In III, for instance, the results of developed specialised production may be regarded as capital. Thus, under I there would be no capital but simply production and consumption from hand to mouth. This method of graphing is only partially and simply developed here, improvements and extended uses naturally suggesting themselves ; but it is possible that by this means clear vision leading to right action may be obtained where heretofore anything but clear vision, with its consequent indecisive and wavering action, has been all too much in evidence.

With the "new order of intelligence" which we see gradually taking charge of our industrial activities, we may well believe that in the future industry will more and more gravitate into the hands of the super-efficient people, and the man who to-day may boast that he can purchase for £5 all the technical skill needed, to-morrow will either have to recognise the breaking of science and scientific methods into industry, and thankfully accept the proffered assistance, or gradually submit to being beaten in the world's markets—apparently by economic conditions, but actually by the efficiency of others being matched against his comparative inefficiency. And it is not the individual expert only we require, but the intelligent rank and file, the level of intelligence of which appears to determine the level of intelligence of the controller and expert.

CORRESPONDENCE.

REPORT ON THE SOCIETY'S EXAMINATIONS.

Will you allow me to call the attention of readers of the *Journal* to some remarks of the Examiners in this excellent and useful Report, *e.g.*, "The want of intelligence on the part of the candidates in reading the questions," etc. (page

824), "the deficiency in common sense," the large number of failures in Arithmetic (Page 822), "elementary mistakes in spelling," the bad spelling of typists (page 823).

In this way the Examiners are continually emphasising the unsatisfactory state of elementary education in this country. The cause is not difficult to discover.

The teacher's time is wholly occupied in explaining away our illogical print, while he is endeavouring, contrary to natural physiological laws, to make the child do something with his hand and his eyes, contradicting that which he does with his mouth and ears. Children are born with common sense, but this is destroyed in early years by a so-called education, which costs this nation £18,000,000 a year.

If the habit of reading *out loud* the results of an arithmetical calculation were adopted in school, the absurdity of "One thousand, one hundred and thirty one million, six hundred and forty two thousand, one hundred and fifty nine pounds, twelve shillings and eight pence," as the cost of a gravelled garden path, would have been discovered by the student himself, but neither pronunciation, nor reading aloud is taught, nor can be taught without a logical notation, such as is used in music, chemistry, mathematics and all other sciences.

Oral Examinations (page 827).

A logical International Notation for all Speech Sounds would enable any student to read all languages at sight and to write down in a rational shorthand anything that the examiners dictate, exactly as he hears it, after which he can transcribe it into the ordinary printed form of the language used. Ordinary dictation is merely a temptation to the student to imprint upon his brain false visual impressions, in the vain hope that they may be erased by future impressions or corrections.

Unless the printer can be induced to bring his art up to date, and to write down what we say, and what we mean, there is no hope of any improvement in education, or any advance in civilisation. Professor Daniel Jones promises us new letters in three hundred years, but three hundred *days* is quite sufficient for the printer to adopt a simple international notation by means of which he can send the English language along with the commercial traveller wherever we wish to sell English manufactures.

A. DEANE BUTCHER.

NOTES ON BOOKS

EMBROIDERED AND LACED LEATHER. By Ann Macbeth. London: Methuen & Co., Ltd. 3*s*. 6*d*. net.

Leather is a very attractive material to work with, and numberless articles of use and beauty may be made out of it in one's spare time; but in spite of these points in its favour few women take up leatherwork compared with the many who spend their leisure on, say, embroidery or knitting. This is possibly because they are scared of it; the tools are unfamiliar, and they do not know how or where to start. It is for such as these that Miss Macbeth's handbook is devised. The essential tools are not numerous and are easily mastered, and the beginner will be surprised to learn with how slender an equipment work of quite a presentable kind may be turned out. Such things as hats, waistcoats, bags, blotters, gloves, etc., may be produced by any one who will follow the instructions given in this book.

It is hardly necessary in this *Journal* to labour the advantages of any handcraft. The person who has designed and executed a piece of work, however simple, has experienced something of the joy of an artist and has also rendered himself more capable of appreciating the beauties of other people's work. It is to be hoped that those who read Miss Macbeth's book will not be content to follow her instructions, but will be tempted, as she hopes they may be, to originate patterns for themselves. There is something in the very nature of leather which seems to stimulate invention; the material itself is delightful to handle; the colours are soft and harmonious, and the most pleasing results may be obtained by the most simple means. We earnestly hope that this handbook may lead to the craft being taken up much more widely than it is at present in such places as Women's Institutes, Girls' Clubs, and Continuation Schools.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, NOVEMBER 17. .. Cold Storage and Ice Association, at the ROYAL SOCIETY OF ARTS, John Street, Adelphi, W.C., 5.30 p.m.

Arts, Royal Academy of, Burlington House, Piccadilly, W., 4 p.m. Dr. A. P. Laurie, "Methods of Wall Painting."

Chemical Industry, Society of, Joint Meeting with the Institution of Rubber Industry, at the Engineers' Club, Coventry Street, W., 8 p.m. Dr. A. Van Rossem and Mr. B. D. Porritt, "Latex: its Chemistry and the Development of its Industrial Applications."

Geographical Society, 135, New Bond Street, W., 8.30 p.m. Mr. M. W. Hilton-Simpson, "The Peoples of the Aures Massif."

Textile Institute, at the Clothworkers' Hall, 41, Mincing Lane, E.C., 5.45 p.m. Mr. H. B. Heylin, "Principles of Construction of Fabrics for particular purposes."

Faraday Society, at the Chemical Society, Burlington House, Piccadilly, W., 8 p.m. 1, Messrs. R. W. E. B. Harman and F. P. Worley, "The Hydrolysis of Alkali Cyanides in Aqueous Solution." 2, Dr. A. P. Laurie, "Note on the Expansion of Water while Freezing." 3, Mr. S. S. Joshi, "The Viscosity of Reversible Emulsions." 4 (a), Mr. D. B. MacLeod, "On the Viscosities of Liquids at their Boiling Points." (b), Mr. D. B. MacLeod, "The Kinetic Theory of Evaporation." 5, Messrs. J. T. Howarth and F. P. Burt, "New Design for Apparatus to Measure the Coefficient of Deviation from Boyle's Law, and the Determination of this Coefficient for Acetylene."

Electrical Engineers, Institution of, (Mersey and North Wales Centre), The University, Liverpool, 7 p.m. Messrs. J. D. Cockroft, R. T. Coe, J. A. Tyacke and Prof. M. Walker, "An Electric Harmonic Method of Analysis."

British Architects, Royal Institute of, 9, Conduit Street, W., 8 p.m. Mr. H. Bagenal, "Planning for Good Acoustics."

Mechanical Engineers, Institution of, (Graduates' Section), Storey's Gate, S.W., 7 p.m. Mr. L. Pendred, "The Production of a Modern Technical Journal."

University of London, King's College, Strand, W.C., 5.30 p.m. Dr. R. W. Seton-Watson, "Austria Hungary, 1867-1918." (Lecture VII.)

People's League of Health, at the Medical Society, 11, Chandos Street, W., o p.m. Sir Robert Armstrong-Jones, "Fatigue and Sleep."

East India Association, Caxton Hall, Westminster, S.W., 3.30 p.m. Major-General Sir Gerald Giffard, "Some Aspects of the Future of Medicine in India."

TUESDAY, NOVEMBER 18 .. Statistical Society, at the ROYAL SOCIETY OF ARTS, John Street, Strand, W.C., 5.15 p.m. Mr. G. U. Yule, President's Address: "The Growth of Population and the Factors which Control it."

Illuminating Engineers' Society, at the ROYAL SOCIETY OF ARTS, John Street, Strand, W.C., 8 p.m. Opening meeting of the session.

Civil Engineers, Institution of, Great George Street, S.W., 6 p.m. Mr. W. J. Hadfield, "Notes on Modern Practice in Road Making."

Botanic Society, Inner Circle, Regent's Park, N.W. Prof. Bickerton, "The Forces of Nature."

Marine Engineers, Institute of, 85, The Minories, E., 6.30 p.m. Mr. J. McGovern, "The Influence of Internal Combustion Engines on the Design of Merchant Ships."

Anthropological Institute, at the London School of Economics, Houghton Street, W.C., 8.15 p.m. Capt. M. W. Hilton-Simpson and Mr. J. A. Haessler, "Native Life in the Algerian Hills illustrated by the Cinema."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Meeting of the Scientific and Industrial Group.

Arts, Royal Academy of, Burlington House, Piccadilly, W., 4 p.m. Dr. A. P. Laurie, "The Theory of Colour and its Application to Painting."

Electrical Engineers, Institution of, (East Midland Sub-Centre), The College, Loughborough, 6.45 p.m. Mr. W. Lawson, "General and Technical Ideas from the Experience of a Meter Engineer."

University of London, King's College, Strand, W.C., 5.30 p.m. Sir Bernard Pares, "Contemporary Russia from 1861." (Lecture VII.)

5.30 p.m. Miss Hilda D. Oakley, "The Philosophy of the Absolute in English Thought." (Lecture I.)

Sanitary Institute, 90, Buckingham Palace Road, S.W., 6 p.m. Miss J. N. B. Paterson "The Economic Value of the Healthy Infant and the New Zealand Welfare Work of the State."

WEDNESDAY, NOVEMBER 19 .. United Service Institution, Whitehall, 3 p.m. Colonel J. F. C. Fuller, "Progress in the Mechanicalisation of Modern Armies."

Meteorological Society, 49, Cromwell Road, S.W., 5 p.m.

Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

Microscopical Society, 20, Hanover Square, W., 8 p.m. 1. Mr. G. R. de Beer, "Comparative Histology and Cytology of the Pituitary Body. 2. Miss J. Latter, "Pollen Development in Lathyrus." 3. Dr. W. N. F. Woodland, "Some Remarkable Caryophylloeids from Siluroid Fishes of the Sudan."

Constructive Birth Control, Society for, Essex Hall, Essex Street, Strand, W.C., 8 p.m. Dr. C. W. Saleeby, "Heredity and Degeneracy—Some New Discoveries."

Arts, Royal Academy of, Burlington House, Piccadilly, W., 4 p.m. Dr. A. P. Laurie, "Some English Cathedrals and Stone Decay."

University of London, King's College, Strand, W.C., 5.30 p.m. Prof. B. O. E. Ekwall, "English Place Names." (Lecture I.)

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. (Students' Meeting.) Address by Mr. P. W. Thomas.

THURSDAY, NOVEMBER 20 .. Women House Property Managers, Association of, at the ROYAL SOCIETY OF ARTS, John Street, Strand, W.C., 5 p.m.

Royal Society, Burlington House, Piccadilly, W., 4 p.m. General Meeting to consider Annual Report of Council.

Chemical Society, Burlington House, Piccadilly, W., 8 p.m.

Linnean Society, Burlington House, Piccadilly, 5 p.m.

Antiquaries, Society of, Burlington House, Piccadilly, W., 8.30 p.m.

Mechanical Engineers, Institution of, (Midland Section), Queen's Hotel, Birmingham, 7.30 p.m. Mr. F. W. Suffield, "The Design of an Up-to-date Factory."

(North-Western Section), at the Engineers' Club, Manchester, 7 p.m. Messrs. W. S. Burge and P. J. Chittenden, "Reducing or Pass-out Turbines."

Mining and Metallurgy, Institution of, at the Geological Society, Burlington House, Piccadilly, W., 5.30 p.m.

London County Council, Geffrye Museum, Kingsland Road, E., 7.30 p.m. Mr. L. A. Shuffrey, "The English Fireplace."

Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C., 6 p.m. Mr. G. Rogers, "Automatic and Semi-Automatic Mercury-Vapour Rectifier Substations."

University of London, King's College, Strand, W.C., 5.15 p.m. Dr. A. W. Reed, "Social and Political Ideas of some Great Thinkers of the Renaissance and Reformation." (Lecture V), "Sir Thomas Moore."

5.30 p.m. Señor O. V. Salomón, "Peru, Old and New." (Lecture I.)

5.30 p.m. Prince D. S. Mirsky, "The Russian Novel from Turgenev to Chekhov." (Lecture VII.)

At the Bedford College for Women, Regent's Park, N.W., 5.15 p.m. Lecture by Dr. J. S. Eakins.

FRIDAY, NOVEMBER 21 .. Central Asian Society, at the Royal United Service Institution, Whitehall, S.W., 5 p.m. Lord Thomson, "My Impressions of a Tour in Iraq."

Metals, Institute of (Sheffield Section), 198, West Street, Sheffield, 7.30 p.m. Mr. A. Marks, "Non-Ferrous Metals in the Foundry."

Photographic Society, 35, Russell Square, W.C., 7 p.m. Meeting of Pictorial Group.

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W., 6 p.m. Report of Research Committee on "Marine Oil-Engine Trials."

University of London, King's College, Strand, W.C., 5.30 p.m. Dr. O. Vocadlo, "Three Champions of Bohemian Reformation." (Lecture III.)

5.30 p.m. Prof. E. G. Coker, "Scientific Method."

Shakespeare Association, King's College, Strand, W.C., 5.30 p.m. Dr. C. Sisson, "Shakespeare in the Bombay Bazaar."

CONTRIBUTIONS TO THE READING ROOM.

The Council acknowledge, with thanks to the Proprietors, the receipt of the following Transactions, of Societies and other Periodicals :—

TRANSACTIONS, ETC.

African Society, Journal.
American Academy of Arts and Sciences, Proceedings.
American Chemical Society, Journal.
American Institute of Electrical Engineers, Transactions.
American Leather Chemists' Association, Journal.
American Philosophical Society, Proceedings and Transactions.
Architectural Association, Journal.
Auctioneers' and Estate Agents' Institute, Journal.
Australasian Association for the Advancement of Science, Report.
Bath and West of England Society, Journal.
British Cold Storage and Ice Association, Proceedings.
British Dental Association, Journal.
Canada, Royal Society, Proceedings and Transactions.
Central Chamber of Agriculture, Journal.
Chartered Institute of Patent Agents, Transactions.
Chemical Society, Journal.
Chicago, Field Museum of Natural History, Publications.
Cleveland Institution of Engineers, Proceedings.
Commonwealth Institute of Science and Industry, Bulletin.
East India Association, Journal.
Farmers' Club, Journal.
Franklin Institute, Journal.
Geneva, Société des Arts, La Revue Polytechnique.
Geological Society, Quarterly Journal.
Geologists' Association, Proceedings.
Glasgow, Royal Philosophical Society, Proceedings.
Imperial Arts League, Journal.
Imperial Institute, Bulletin.
India, Geological Survey, Memoirs and Palæontologia Indica.
Indian Meteorological Department, Monthly Weather Review.
Institute of Bankers, Journal.
Institute of Brewing, Journal.
Institute of British Carriage and Automobile Manufacturers, Journal.
Institute of Chemistry, Journal and Proceedings.
Institute of Metals, Journal.
Institute of Sanitary Engineers, Journal.
Institute of Transport, Journal.
Institution of Automobile Engineers, Proceedings.
Institution of Civil Engineers, Minutes of Proceedings.
Institution of Civil Engineers of Ireland, Transactions.
Institution of Electrical Engineers, Journal.
Institution of Engineers and Shipbuilders in Scotland, Transactions.
Institution of Gas Engineers, Transactions.
Institution of Mechanical Engineers, Journal and Proceedings.
Institution of Mining and Metallurgy, Transactions.
Institution of Municipal and County Engineers, Journal.
Institution of Naval Architects, Transactions.
Institution of Petroleum Technologists, Journal.
Iron and Steel Institute, Journal.
Japan Society, Transactions and Proceedings.
Johannesburg, Chemical Metallurgical and Mining Society, Journal.
Junior Institution of Engineers, Record of Transactions.
Kyoto, Imperial University, Memoirs of the College of Science.
Linnean Society, Journal.
Liverpool, Engineering Society, Transactions.
London Society, Journal.
Lyons, Société d'Agriculture, Sciences et Industrie, Annales.
Manchester Literary and Philosophical Society, Memoirs and Proceedings.
———, Municipal School of Technology, Journal.
———Textile Institute, Journal.
Michigan Academy of Science, Reports.
Milan, Associazione Elettrotecnica Italiana, Atti.
National Physical Laboratory, Collected Researches.

New South Wales, Royal Society, Journal and Proceedings.
New York Academy of Sciences, Annals and Memoirs.
New Zealand Board of Science and Art, Journal.
North-East Coast Institution of Engineers and Shipbuilders, Transactions.
Norwich, Operative Brewers' Guild, Journal.
Nova Scotian Institute of Science, Transactions.
Paris, Société d'Encouragement pour l'Industrie Nationale, Bulletin.
——, Société de Géographie Commerciale, Revue.
——, Société des Ingénieurs Civils, Mémoires.
——, Société Internationale des Electriciens, Bulletin.
——, Société Nationale d'Acclimatation de France, Bulletin.
Patent Office, Abridgments of Specifications.
Pennsylvania (Western), Engineers' Society of, Proceedings.
Philadelphia, Academy of Natural Sciences, Proceedings.
Physical Society, Proceedings.
Quekett Microscopical Club, Journal.
Royal Aeronautical Society, Journal.
Royal Agricultural Society, Journal.
Royal Asiatic Society, Journal.
Royal Astronomical Society, Memoirs.
Royal Canadian Institute, Transactions.
Royal Cornwall Polytechnic Society, Annual Report.
Royal Dublin Society, Proceedings and Transactions
Royal Horticultural Society, Journal.
Royal Institute of British Architects, Journal.
Royal Institution of Great Britain, Proceedings.
Royal Irish Academy, Transactions and Proceedings.
Royal Meteorological Society, Quarterly Journal and Record.
Royal National Life-boat Institution, "The Life-boat" and Annual Report.
Royal Sanitary Institute, Journal.
Royal Society, Philosophical Transactions and Proceedings.
Royal Society of Edinburgh, Transactions and Proceedings.
Royal Statistical Society, Journal.
Royal United Service Institution, Journal.
Smithsonian Institution, Report and Publications.
Society of Antiquaries, Archæologia and Journal.
Society of Chemical Industry, Journal.
Society of Dyers and Colourists, Journal.
Society of Engineers, Transactions.
South African Association for the Advancement of Science, Report.
South Wales Institute of Engineers, Proceedings.
Tokyo, Imperial University, Journal of the College of Science.
Tramways and Light Railways Association, Journal.
United States Department of Commerce, Reports.
Victoria Institute, Journal of the Transactions.
Washington National Academy of Sciences, Proceedings.
Wisconsin Academy of Sciences, Transactions.

JOURNALS.

Weekly.

Amateur Mechanic.
Amateur Photographer.
American Machinist.
Architect.
Architecture.
Board of Trade Journal.
Bradstreet's.
British Journal of Photography.
Builder.
Building News.
Cabinet Maker.
Chemical News.
Chemist and Druggist.
Colliery Guardian.
Contract Journal.
Contractors' Record.
Electrical Review.
Electricity.
Engineer.
Engineering.
English Mechanic.
Gardeners' Chronicle.
Gas Journal.
Greater New York.
Grocer.
Indian Engineering.
Iron and Coal Trades Review.
Journal of Agricultural Research (Washington).
Lancet.
Leather.
London County Council Gazette.
London Teacher.
Machinery.
Machinery Market.
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Mechanical World.
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Motor Transport.
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Nature.
Near East.
Notes and Queries.
Paper Trade Review.
Pharmaceutical Journal.
Pitman's Journal.
Produce Markets' Review.
Public Opinion.
Pulp and Paper Magazine of Canada.
Saturday Review.
Scientific American.
Shipping World.
Spectator.
Teachers' World.
Textile Mercury.
Timber News.

Fortnightly.

Dyer and Calico Printer.
Finance Chronicle.
Jeweller and Metalworker.

L'Age de Fer.
Perak Government Gazette.
Revue du Travail.
Revue Générale des Sciences.
West India Committee Circular.

Monthly.

Acetylene and Welding Journal.
Analyst.
Automobile Engineer.
Bookseller.
Brewers' Journal.
British Builder.
British Engineers' Export Journal.
British Trade Journal.
Bulletin Technique du Bureau Veritas.
Cassier's Industrial Management.
Chamber of Commerce Journal.
Chimie & Industrie.
Cold Storage.
Co-partnership.
Cotton (Atlanta).
Decorator.
Empire Production.
Engineering and Boiler House Review.
Engineering Journal (Canada).
Engineering Production.
Engineers and Engineering (Philadelphia).
Export World.
Gas and Oil Power.
Gas Engineer.
Geographical Journal.
Geographical Review (New York).
Giornale del Genio Civile (Rome).
Glass.
Horological Journal.
Ice and Cold Storage.
Illuminating Engineer.
Indian Textile Journal.
Industrial India.
International Sugar Journal.
Journal of the Department of Agriculture (Pretoria).
Journal of the Ministry of Agriculture.
Kew Bulletin.
Leather Trades' Review.
Locomotive.
Master Builder.
Meteorological Magazine.
Miller.
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South African Engineering.
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United Empire.
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Water and Water Engineering.
Welfare Work.

Quarterly.

Agricultural Journal of India.
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NEWSPAPERS.

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Englishman (Calcutta).
Home and Colonial Mail.
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Madras Weekly Mail.
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